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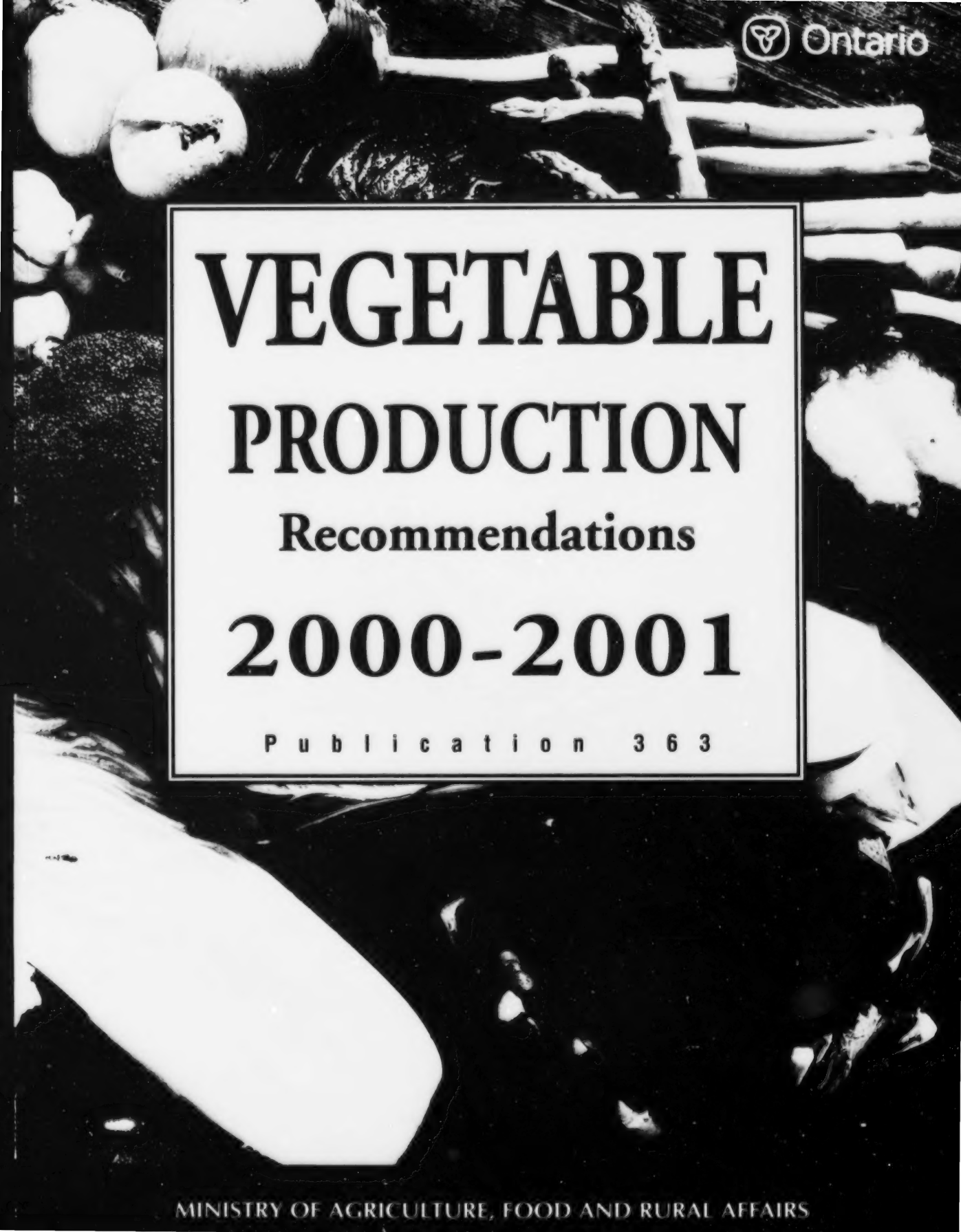


Ontario

VEGETABLE PRODUCTION Recommendations 2000-2001

Publication 363

MINISTRY OF AGRICULTURE, FOOD AND RURAL AFFAIRS

Each year the appropriate sub-committee of the Ontario Pest Management Research and Services Committee reviews the pesticides listed in this publication. To the best knowledge of the sub-committee, all of these pesticides were:

- federally registered
- reviewed by the Ontario Pesticides Advisory Committee and
- classified by the Ministry of the Environment as of November, 1999.

Discard old editions of this publication.

The information in this publication is general information only. All pesticides must be used in accordance with the product label and *Regulation 914* of the Ontario *Pesticides Act.*

Pay close attention to all instructions and warnings on the pesticide label.

By printing this publication, the Ministry of Agriculture, Food and Rural Affairs does not offer any warranty or guarantee, nor does it assume any liability for any crop loss, animal loss, health, safety or environmental hazard caused by the use of a pesticide mentioned in this publication.

Policy Statement

In this publication, most recommendations list several pesticides that can be used for each pest discussed. In general:

- the least hazardous materials and those that growers have used satisfactorily for years are listed first;
- the more toxic pesticides and/or newer ones with less practical, grower experience follow.

In some cases, the most effective pesticides are highly toxic.

This publication lists a number of brand names of pesticides. This is for the grower's convenience only. It is neither an endorsement of the product nor a suggestion that similar products are ineffective.

Weather and other factors influence the effectiveness of pesticides and the likelihood of plant injury by control chemicals. Consult the package label and other information regarding compatibility with other materials, the effect of high or low temperatures, poor drying conditions, and so on. Wettable or soluble powders (WP, SP,WDG or DG) are less likely to cause plant injury than liquid concentrates (EC, SC, and F).

Health Canada has established maximum residue limits (MRLs) for pesticides. However, growers should be aware that processors or retailers may demand more restrictive limits. Growers should seek advice of their intended market as to which restrictions or limitations apply.

Federal Registration and Provincial Classification

The Ministry of the Environment administers Ontario's *Pesticides Act* and *Regulation 914.*

All pesticides sold and used in Ontario must be:

- registered under the federal *Pest Control Products Act*, and
- classified under the provincial *Pesticides Act* by being placed in one of six schedules of the Ontario regulation.

Federal Registration

There are three federal registration categories.

1. **Full Registration**
   The federal government agrees the data package was acceptable at the time of registration.

2. **Temporary Registration**
   Additional scientific or technical information is required to obtain full registration. Temporary registrations expire after a specified time (one or two years).

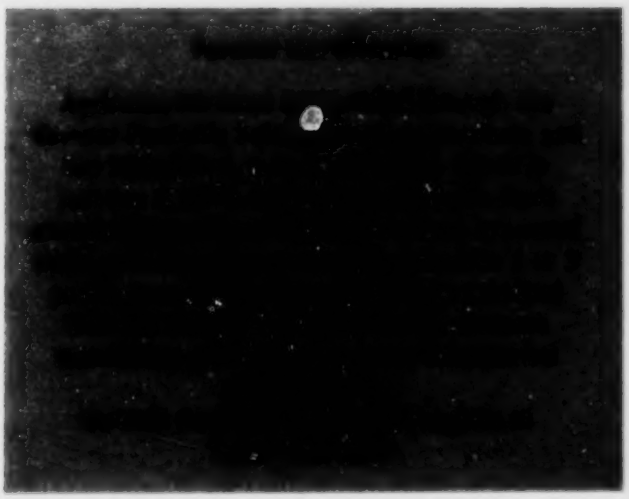
3. **Temporary Registration (Restricted Class)**
   While the pesticide is urgently needed, studies on the safety of the product are incomplete. Such registrations expire on the 31st of December each year and the products must be re-registered yearly.

Provincial Classification

There are six classification schedules in *Regulation 914.* Pesticide products are classified on the basis of their toxicity, environmental or health hazard, persistence of the active ingredient or its metabolites, concentration, and usage. This system is needed to regulate the distribution, availability and use of pesticide products in Ontario.

For up-to-date information on the regulatory status of these or other pesticides contact the:

Pesticides Section,
Standards Development Branch,
Ministry of the Environment, Toronto.
Telephone (416) 327-5519



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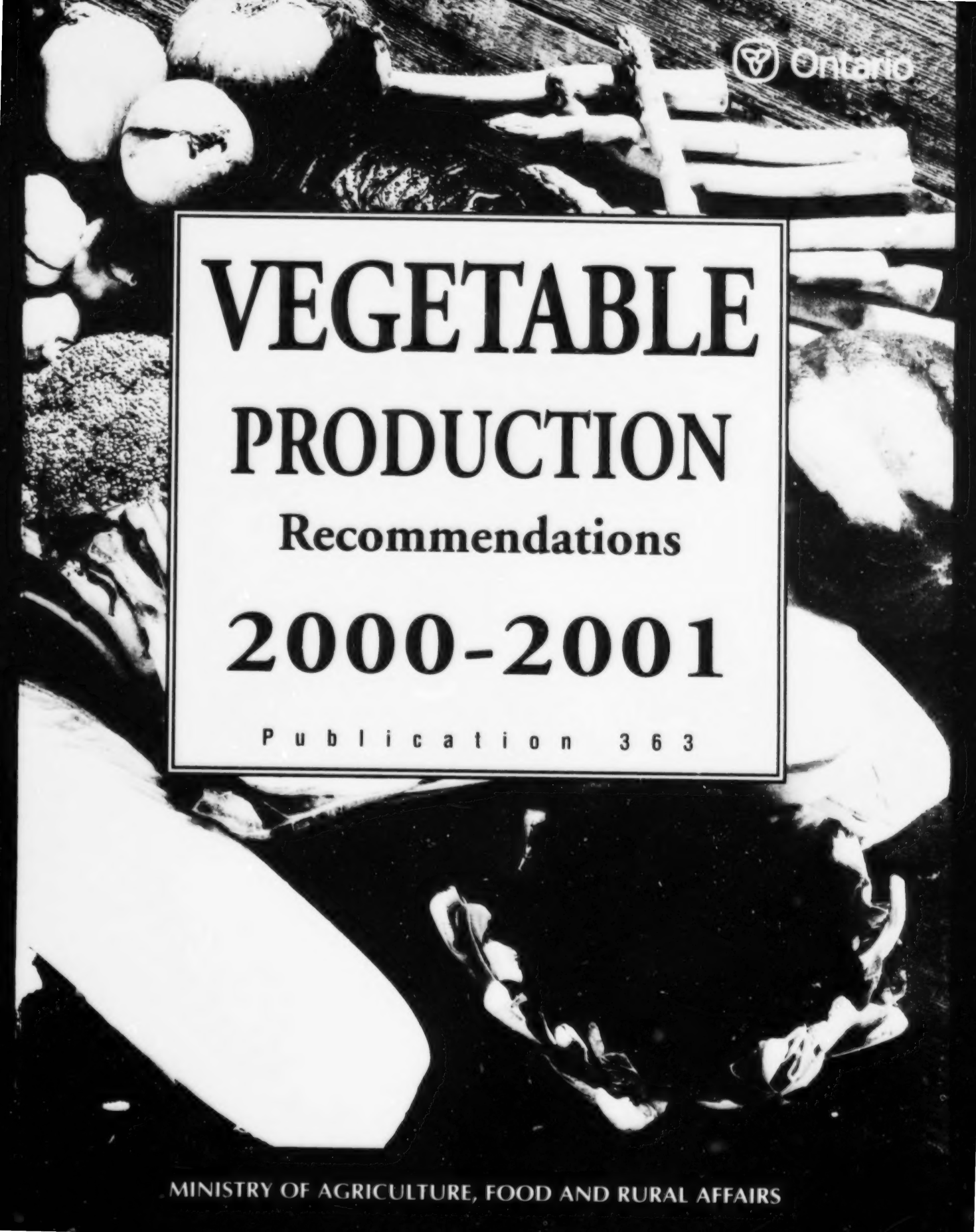

Ontario

VEGETABLE PRODUCTION Recommendations 2000-2001

Publication 363

MINISTRY OF AGRICULTURE, FOOD AND RURAL AFFAIRS

Looking for vegetable production recommendations on the Internet?

www.gov.on.ca/omafra/english/crops/index.html

It's one-stop shopping for factsheets, articles and photos regarding the production and management of Ontario's vegetable crops.

Acknowledgements

The recommendations in this publication have been prepared in consultation with:

- Ontario Pest Management Research & Services Committee
- Ontario Horticultural Research & Services Committee
- Ontario Soil Management Research & Services Committee
- Ontario Weed Committee

and personnel of:

- Crop Technology, OMAFRA
- University of Guelph
- Ontario Ministry of the Environment
- Agriculture and Agri-Food Canada

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100-05541/

1. Pesticides

Pesticide Resistance

Many of the pesticides recommended in this publication have a very specific mode of action, that is, they act on a single system or site in the organism. Using these materials continuously or repeatedly in a season-long program will increase the chances of pest resistance developing.

To reduce the chances of developing pest resistance, this publication recommends that such compounds be used in conjunction with other pesticides or alternated with other pesticides and pest management methods.

Please note that several pesticides may act similarly. Parathion and Guthion, for example, act on the same site, and if resistance develops to one, it is likely to also apply to the other. This is called cross-resistance. Alternating these compounds will not work. Instead, they should be alternated with insecticides with different modes of action, such as Thiodan.

Pesticide Groupings

Throughout this publication, the pesticide group will be listed for each of the recommended active ingredients, for example, cyhalothrin-lambda (Matador) (pyrethroid group). Wherever possible, rotate between groups to reduce the development of resistance. For herbicide groups, consult Table 6–4, *Herbicide Groupings for Ontario,* on page 179.

General Precautions

1. Before using a pesticide, always read the label and follow all precautions and directions. Keep a record of the common names of all the pesticides you handle, especially those listed as hazardous in this publication. Ensure that other members of your family know where the list is, in case there is an accident.

2. Never smoke, chew tobacco or eat while handling or applying pesticides. Do not carry tobacco or food in clothes worn while spraying. Change clothing and wash before eating.

3. When handling and mixing pesticide concentrates, rinsing empty containers or repairing leaks, wear a full set of protective clothing. This includes a waterproof cap, coveralls, impervious gloves and boots, and safety goggles. Always wear a respirator when using extremely toxic pesticides or very dusty formulations. When handling dusty formulations, a dust mask should be worn. If handling volatiles or gases, a respirator should be worn. If these gases are highly dangerous or handled in an enclosed space, a self-contained breathing apparatus may be required. Be sure to follow the specific instructions on the pesticide label.

4. When drawing water from wells, ponds, streams or other sources, use an anti-backflow device to prevent back-siphoning. Mix pesticide at least 50 m from wells, ponds or streams. Triple or pressure rinse the empty container and add the rinse water to the tank. Only mix enough solution to do the spray job. When finished loading and mixing, puncture pesticide container, wash gloves and boots with clean water before removing them.

Always follow the instructions on the label.

5. During application, use a tractor cab with a charcoal filter, which will provide adequate protection against exposure. Wear impervious gloves, boots, coveralls and cap when tending to stoppages. When using airblast and mist blowers or in tractors without cabs, wear waterproof suits and caps and impervious gloves and boots. When applying fumigants in the field, have a respirator on hand in case you need to leave the cab to deal with equipment problems or in case inadequate sealing in the soil allows the fumigant to escape.

6. When the spray operation is complete, bathe or shower to remove pesticide deposits on your skin. Do not handle anything in the home before bathing.

Preventing Contamination of Farm Water Supplies

Pesticides can contaminate well, pond and surface water. It is an offence to contaminate surface waters with pesticides. Taking the following steps will help prevent contamination.

- Store pesticide concentrates in locked storage located above the flood plain level.
- After emptying, triple or pressure rinse, puncture, crush and dispose of containers.
- Return empty plastic or metal containers to a dealer who participates in the container recycling program. Empty bags may be burned or disposed of at a landfill site.
- Mix pesticide and load sprayer at least 50 m away from any water supply.
- Use buffer zones and berms to avoid contaminating surface water, wells, ponds and streams.
- Do not use drinking water sources to fill spray equipment. If you fill your tank from a well, lake, river or other surface-water source, always use an anti-backflow device.
- Spray only at a safe distance from shallow wells and other water supplies. On days with no wind, you may safely spray 10 m or more from shallow wells and 5–10 m or more from other water supplies, farther away if there is any air movement. Do not spray when wind velocity reaches 10 km/hr.

If an Accident Occurs

1. Wash your gloves, boots and respirator before removing them. Remove contaminated clothing, including underclothes, immediately and wash exposed skin thoroughly with soap and water. Soak clothes immediately and double launder them as soon as possible. If the spill was serious, place the clothes in a plastic bag and dispose of them in a safe manner. Wash contaminated gloves, boots and respirator again.
2. If clothing becomes wet with a pesticide, remove it immediately, bathe thoroughly and put on fresh clothes.
3. If symptoms of illness occur during or shortly after handling a pesticide, go to a hospital and take a list of pesticides with you. (See *Emergency Procedures for Pesticide Poisoning* on the inside back cover.)
4. Clean up any pesticide spills immediately. In the case of minor spills, use dry soil or other absorbent material such as kitty litter to remove excess liquid. Sweep up powders and granulars. Contaminated soil and sweepings should be spread over a large area of bare soil to facilitate rapid degradation. Make sure you are adequately protected when cleaning up the spill. For information on preventing spills, see the OMAFRA Factsheet, *Ways to Avoid Pesticide Spills*, Order No. 96-025.

In the case of a major pesticide spill, you must notify:
the Ministry of the Environment
Spills Action Centre
5775 Yonge St., Suite 1005
North York, Ontario, M2M 4J1
1-800-268-6060 or (416) 325-3000

5. If a well becomes contaminated, consult the *Best Management Practices* booklets 12 (*Water Wells*) and 13 (*Pesticides*) for more information.

Emergency Procedures for Pesticide Poisoning and First-Aid Information
(See inside back cover.)

Relative Toxicity to Applicator

Definitions

Lethal Dose 50% (LD_{50}) The dose that, when administered, will kill 50% of the test animals within a stated period.

Acute Toxicity Immediate adverse effects from a single or short period of exposure to a substance, either by the oral, dermal or inhalation route.

Chronic Toxicity Adverse effects resulting from repeated exposure to a substance over an extended period.

High Acute Toxicity

These pesticides are extremely dangerous if handled carelessly. The acute oral LD_{50} is less than 50 mg/kg of body weight, and the acute dermal LD_{50} is less than 200 mg/kg

of body weight. These pesticides can be fatal if less than 0.1–3.0 mL (1 drop to half a teaspoon) is taken. These pesticides are labeled with the skull and crossbones in a stop sign. A respirator and eye protection along with all other protective clothing must be worn when using these products:

Common name	Trade name
azinphos methyl	Guthion, APM, Sniper
carbofuran	Furadan
disulfoton	Di-Syston
endosulfan	Thiodan, Thionex
methamidaphos	Monitor
methomyl	Lannate
oxamyl	Vydate
parathion	Parathion
phorate	Thimet
terbufos	Counter

Moderate Acute Toxicity

These pesticides are dangerous if handled carelessly. The acute oral LD_{50} is 50–500 mg/kg of body weight, and the acute dermal LD_{50} is 200–2,000 mg/kg of body weight. These pesticides can be fatal if as little as 3–30 mL (half a teaspoon to 2 tablespoons) is ingested. These pesticides are labeled with the skull and crossbones on a stop sign. A respirator should be worn when handling these concentrates:

Common name	Trade name
m-isothiocyanate/ dichloropropene/chloropicrin	Telone, Vorlex
chlorpyrifos	Lorsban, Pyrifos
deltamethrin	Decis
diazinon	DZN
dimethoate	Cygon, Lagon
phosmet	Imidan
pirimicarb	Pirimor
cyhalothrin-lambda	Matador

Low Acute Toxicity

These pesticides are not fatal unless deliberately ingested in amounts of over 30 mL (1 oz.). The acute oral LD_{50} is greater than 500 mg/kg body weight, and the acute dermal LD_{50} is greater than 2,000 mg/kg body weight. Pesticides listed in this publication but not in the lists in this section have low acute toxicities. Handle them with caution. Wear protective clothing and safety goggles. If using these products in a confined space, wear a respirator.

Chronic Toxicity

It is not possible to assess the chronic toxicity of a pesticide in the same way an LD_{50} is used to determine acute toxicity. Instead, a number of tests performed on animals help predict whether a pesticide may cause long-term effects. Animals are examined for a wide variety of toxic effects such as the production of tumors or abnormalities. Using protective clothing and equipment will help reduce exposure and the risk of chronic effects.

Entering Treated Areas

Workers may be poisoned if they enter fields without wearing protective equipment too soon after pesticides have been applied. Such poisoning can result from handling treated plants or from inhaling pesticide vapours. The list below shows a specific minimum interval that you must observe between applying pesticide and working in the crop without protective equipment. Some pesticides, like parathion, have labels that carry a warning about working in treated crops. Follow the label's recommendations.

Otherwise, keep to the following minimum intervals:

12 hours	vinclozolin (Ronilan), fosetyl-al (Aliette)
24 hours	methomyl (Lannate), oxamyl (Vydate), cyhalothrin-lambda (Matador)
48 hours	azinphos-methyl (Guthion, APM, Sniper), oxyfluorfen (Goal) (for males and women of non-child-bearing age), carbofuran (Furadan),[1] methamidaphos (Monitor)
6 days	oxyfluorfen (Goal) (for women of child-bearing age)
7 days	parathion

[1] If planning prolonged direct contact with corn foliage, do not enter fields treated with Furadan within 14 days of application without wearing protective equipment.

Blood Tests for Those Applying Pesticides

Organophosphorus and carbamate pesticides are capable of inactivating serum and red blood cholinesterase levels. If cholinesterase activity falls below a critical level, poisoning can result. Symptoms include fatigue, dizziness, nausea, trembling, blurred vision and difficulty breathing.

Before using these groups of pesticides, have the family doctor check your cholinesterase levels. To be of value, the tests should be started before these pesticides are used, since the normal level can vary considerably,

making it difficult to assess the degree of suppression. In this publication, the insecticides of primary concern are:

Common name	Trade name
azinphos-methyl	Guthion, APM, Sniper
carbaryl	Sevin
carbofuran	Furadan
chlorpyrifos	Lorsban, Pyrifos, Pyrinex
diazinon	DZN
dimethoate	Cygon, Lagon
disulfoton	Di-Syston
methomyl	Lannate
phosmet	Imidan
phorate	Thimet
terbufos	Counter
oxamyl	Vydate
parathion	Parathion
pirimicarb	Pirimor

Protective Outdoor Clothing

Why Use Personal Protection?

Pesticide formulations vary in toxicity from slightly to extremely poisonous. Exposure occurs once the pesticide is removed from the container. The toxicity of the pesticide and exposure to the user create a hazard. You can reduce the hazards of spraying and thus the risk of poisoning. Wearing protective clothing reduces the risk.

Stage	Risk level
Handling and mixing concentrate	very high risk
Rinsing empty containers	high risk
Applying outdoors	low-to-high risk
Applying indoors	medium-to-very-high risk
Cleaning up, rinsing equipment	medium-to-high risk
Entering treated area within 48 hours	low-to-very high

Reducing Exposure

Exposure can be through skin, eyes, mouth or nose. About 80–85% of the exposure in most spray operations is during mixing and loading concentrate. Field application usually accounts for 15–20% of the exposure. Skin exposure is usually 90–100% of the total exposure. Around 70% of this is by way of the hands and forearms, and 30% involves the rest of the body. Inhalation (nose and mouth) exposure is normally 0.1% but rises to 5–10% with mist blowers and air blast sprayers.

Protective Clothing

To reduce skin (dermal) exposure, wear impervious gloves. Always refer to the product label. Unless the label says otherwise, use neoprene or nitrile gloves. Always wear waterproof boots, along with coveralls, apron or spray suits and waterproof cap. Coveralls can be reusable or disposable. Reusable coveralls are normally cotton or polyester and should be tightly woven. It's easier for the pesticides to penetrate polyester than cotton.

Disposable coveralls are polyethylene and may be laundered several times. Spray suits should be used in highly hazardous conditions such as with mist blowers and air blast machines. Protect your eyes with safety goggles when working with any pesticide concentrate.

Respirators

Use respirators when handling pesticides with labels that call for respiratory protection and carry the warning stop sign with skull and crossbones. Use respirators when spraying any pesticide rated as high toxicity or when applying any liquified gas. Respirators are available as air purifiers or self-contained units and come in a wide range of shapes and sizes. Consult the label and your nearest safety supply company for advice. Make sure the cartridge or canister you use has a safety-approved sticker with the letters NIOSH (National Institute for Occupational Safety and Health) on it.

Washing Protective Clothing

To keep your protective clothing and equipment functional, clean it thoroughly. Never let children or pets come in contact with contaminated clothing or equipment. Launder clothing promptly, wash and store other personal protection items and rinse spray equipment and store it away so children can't play with it.

Fabric Clothing

If fabric is saturated with the concentrate of a highly toxic pesticide, dispose of the material safely. Wear nitrile or neoprene gloves when handling severely contaminated clothing. Remove the clothing carefully, immediately put it in a plastic bag and dispose of it in a safe manner. For a normal spray operation, follow these guidelines, preferably twice a day, but at least at the end of the work day:

- Rinse clothing outdoors.
- Soak and wash protective clothing separately from other clothes.
- Soak protective clothing, with detergent, in a container such as a large bucket or tub; or use the pre-wash cycle of an automatic washer, with detergent. Pre-wash solvent-based products work on EC formulations.
- Wash only a few garments at a time.
- Use heavy-duty liquid detergents.
- Use hot water, the highest water level, and a regular hot, super-wash cycle.

TABLE 1–1.

Safety Supply Companies in Ontario Providing Protective Clothing or Respiratory Devices

Manufacturer	Available from	Branches/Web site	Telephone
E.A.R., AO Safety, Peltor, Eastern	Aearo Canada Ltd. 7115 Tomken Road Mississauga, Ontario L5S 1X7	www.aearo.com	(905) 795-0700
H.S. Cover, Survivair	Levitt-Safety Ltd. 2872 Bristol Circle Oakville, Ontario L6H 5T5	Kitchener, London, Oakville, Ottawa, Sarnia, Stoney Creek, Sudbury, Thunder Bay	(905) 829-3299 1-888-453-8488
Kasco Helmets	The St. George Co. P.O. Box 430 20 Consolidated Dr. Paris, Ontario N3L 3T5	www.thestgeorgeco.com	(519) 442-2046 1-800-461-4299
Mine Safety Appliances	MSA Canada Inc. 148 Norfinch Drive North York, Ontario M3N 1X8	www.msacanada.com	(416) 667-9400 1-800 267-0672
3M Canada Inc. Occupational and Environmental Safety Division	A wide range of distributors: Contact: P.O. Box 5757 London, Ontario N6A 4T1	http://international.3m.com/intl/CA/english/index	(519) 451-2500
North Safety Products Ltd.	North Safety Products 26 Dansk Court Toronto, Ontario M9W 5V8	www.northsafety.com/home	(416) 675-2810 1-800-268-6925
Racal Airstream, Scott, Willson	Acklands-Grainger Inc. 90 West Beaver Creek Road Richmond Hill, Ontario L4B 1E7	Hamilton, Kingston, Kitchener, London, St. Catharines, Sarnia, South Porcupine, Thunder Bay, Windsor www.acklands.ca	1-800-387-5744
Medical Safety First Aid	Kit Care Corp. 91 Kelfield St., Unit 6 Rexdale, Ontario M9W 5A4	Kitchener, London, Orillia, Ottawa, St. Catharines, Stoney Creek	(416) 243-3030

Many of these companies also have dealer outlets. For details, contact the supply company.

- Do two complete wash cycles, each with a double rinse.
- After washing, run another wash cycle with detergent and no clothing to decontaminate the washing machine.
- Hang the clothes to dry, outside if possible, to avoid a potential build-up of pesticide residue in the dryer.

Rubber, Vinyl or Plastic Boots and Gloves

To avoid getting pesticide on your hands, wash the outside of your boots and gloves with detergent and water before taking them off. After removing boots and gloves, wash them inside and out with detergent and water, rinse them thoroughly and dry them in a well-ventilated area.

Chemical-Resistant Clothing, Goggles and Face Masks

Wash plastic or rubber clothing and equipment with detergent and water, rinse thoroughly and dry in a well-ventilated area.

Respirators

Discard cartridges, canisters and filter pads when breathing becomes difficult, when you notice a pesticide odour, or at the interval set by the manufacturer. Make a note of the date the cartridge is first used. Remove cartridges and filter pads from the face piece and store them in clean, sealed plastic bags. Wash the face piece in detergent and water, rinse it thoroughly, and dry it in a well-ventilated area. Never use alcohol or other solvents for cleaning, as they will damage the rubber and plastic.

Selecting Protective Clothing

Consult a safety supply company when selecting proper protective clothing. (See Table 1–1, *Safety Supply Companies in Ontario Providing Protective Clothing or Respiratory Devices*, above.)

Protective Devices to Be Used in Enclosed Areas

Canister Gas Masks

Canister gas masks are effective for protection against certain harmful gases, vapours and particulate matter. They are generally suitable for ventilated areas not subject to rapid change, but should never be used in confined spaces where oxygen deficiency and high gas concentrations may occur.

Self-Contained Breathing Apparatus

An air-purifying apparatus will not work in confined spaces where gas concentrations are unusually high. The lack of oxygen can prove fatal. Under these conditions, use an air supply provided by a self-contained breathing apparatus (such as Scott Air Pack). Using substances that produce hydrogen cyanide, methyl bromide, chloropicrin or phosphine can produce high gas concentrations and oxygen deficiency as can smoke generators, foggers using highly toxic pesticides and some volatile sprays.

Other Protective Clothing

Wear other protective clothing in keeping with requirements listed on the pesticide label.

Working Conditions

Use canister gas masks when the surrounding air contains low concentrations of toxic gases, vapours or particulate matter derived from soil-drench, granular, dust or foliar spray applications. Pesticides applied in this manner usually have moderate to low toxicity. Always use a self-contained breathing apparatus when applying highly toxic pesticides. These can produce high concentrations of toxic gases, vapours or particulate matter, and a lack of oxygen, especially in an enclosed space (e.g., when fumigating grain). Contact a safety supply company for further recommendations.

Space Fumigants and Insecticide Smokes

Learn about the health hazards and toxic properties of the pesticide you are using.

When using fumigants or insecticide smoke generators, wear protective clothing to prevent skin and inhalation exposure. During and after treatment, lock the building and post warning signs. Follow the instructions on the product label regarding aeration of treated buildings, warehouses or greenhouses before letting anyone enter.

Fumigants

An agriculturalist using methyl bromide plus chloropicrin or aluminum phosphide to fumigate greenhouses, vaults, warehouses and grain storage must obtain a permit issued under the *Pesticides Act*. To apply for a permit, contact the local pesticides officer with the Ministry of the Environment. As a safety precaution, have someone else who is wearing personal protective equipment help with the fumigation.

Always consult the product label.

Do not wear gloves when handling methyl bromide, because these will trap gas next to the skin. Wear a full-face respirator with the proper organic vapour canister or positive pressure breathing apparatus. When handling aluminum phosphide, use cotton gloves and wear a full-face mask respirator with an acid gas canister.

For more information, refer to *Methyl Bromide Structure Fumigation Procedures* and *Aluminum Phosphide Structure Fumigation Procedures* from the Ministry of the Environment.

Storing Pesticides

The *Ontario Pesticides Act* and *Regulation 914* require that all pesticides be kept out of the reach of children, irresponsible persons, pets and livestock. They should be stored in a locked facility away from food and feed. Herbicides should be stored separately from other pesticides to avoid contamination.

Always store pesticides in their original containers and keep them tightly closed. Never put pesticides in unmarked containers. In areas where flooding has been frequent, you must store fertilizers and pesticides above the known high-water mark. Contamination of water by these chemicals may lead to serious health problems for humans and domestic animals as well as fish and wildlife.

See also the OMAFRA Factsheet, *Pesticide Handling Facility*, Order No. 94-037.

Schedule 1, 2 and 5 pesticides

Schedule 1, 2 and 5 pesticides must be stored in a locked facility that is ventilated to the outside. A sign that says CHEMICAL STORAGE WARNING — AUTHORIZED PERSONNEL ONLY in block capitals must be fixed to the outside of each entrance. Only the certified agriculturalist or someone under that person's supervision can enter the storage facility.

Disposal of Pesticide Containers or Contaminated Material

All paper or cardboard pesticide containers, paper packaging material or other paper material used to clean up spills should be burned or disposed of at a landfill site.

Make sure that people and animals are kept away from the smoke and that the smoke is not directed toward buildings, highways, roads or outdoor public areas. Plastic material must not be burned.

Unrinsed containers can contain as much as 3% of the original formulation. Discarding this amount of toxic pesticide with the container could be dangerous to other people handling it or to the environment (for example, your water supply). Why waste that 3%? Use it to control the pest!

Rinse all metal, plastic or glass containers three times with water and add the washings to the spray tank. Or use a rinsing device. These rinsers can be used to puncture the bottom of a metal or plastic container and rinse the residue directly into the spray tank. This procedure takes less than a minute. Return the rinsed containers for recycling to any dealer cooperating in the pesticide container collection and recycling program.

Dispose of unwanted or contaminated pesticide through Laidlaw Environmental Management at (519) 451-6630, or contact the appropriate registrant at (416) 327-5519 to develop an alternative method acceptable to the director under the *Pesticides Act*.

Sprayers

Herbicide sprayers that can deliver enough litres per hectare for adequate coverage are satisfactory for applying emulsion-type insecticides. However, if 2,4-D or related herbicides have been used in them, the sprayers will have to be cleaned thoroughly, or foliage may be damaged. The detergent used should contain ammonia.

For applying the wettable powder formulations, use a high-capacity (450 L/ha), high-pressure, piston pump sprayer with an agitator. Keep in mind that the higher the pressure, the greater the risk of drift to other crops.

Calibrate your sprayer at least twice during the growing season. The wear on nozzles and other parts will alter the amount of spray delivered.

Band Spraying of Pesticides

When banding insecticides, apply the recommended rate over the strip of row you wish to treat. While banding does not result in a more concentrated spray mixture, it does allow you to cover more area with the same amount used in a broadcast application. For example, if you are treating only a third of the row width, you will be able to cover three times the area compared to a broadcast application.

Application by Airplane or Helicopter

Aerial applicators must be licensed by the Ontario Ministry of the Environment to apply pesticides. In addition, they need permits from the same ministry to apply Schedule 1 and 5 pesticides and Schedule 2 hormone-type herbicides. Ministry personnel will inspect the area to ensure the application is done safely.

It is an offence under the federal *Pest Control Product Act* to use a control product under unsafe conditions. Precautions must be heeded at all times to prevent drift. Extra precautions should be taken when using insecticides applied by air, especially those known to be toxic to honeybees.

Applications should not be made if the wind is blowing. Even on the calmest day, some drift occurs. To keep it to a minimum, apply pesticides in the evening or early morning.

Be sure that the contract specifies the product to be used and its rate of application. Only products specifically allowing aerial use may be applied by aircraft.

Pesticide Drift

Pesticide drift can leave residues on adjacent crops, be a hazard to nearby people and livestock and reduce the amount of material in the target area so that it is ineffective. People applying pesticides should make every effort to minimize or prevent pesticide spray drift by:

- correctly calibrating and maintaining spray equipment
- operating the equipment correctly
- being aware of the toxicity of the pesticide being used
- being aware of the weather conditions
- observing all set-back or buffer zone requirements on the label

Growers are responsible for any material discharged from their sprayers no matter where it is found. This includes liability for adverse effects such as damage to crops or to ornamental plants and illegal or unacceptable residue on neighbours' crops or property. Applicators are also responsible for injury resulting from car accidents caused

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by windows smeared by spray drift or any allergic or asthmatic reactions of bystanders even if they are not on your property. Take all precautions necessary to prevent drift off site that might implicate you in any damaging action.

For more information, consult:

- OFA/OMAFRA/AAFC booklet, *Best Management Practices – Pesticide Storage, Handling and Application*
- Ridgetown College video *How to Manage Spray Drift*

Residue Tolerances and Days to Harvest

Some pesticide residues disappear quickly, whereas others may persist for certain periods. Residue tolerances for vegetable crops have been established by Health Canada and are monitored regularly by federal and provincial authorities.

To avoid exceeding the residue tolerance for insecticides, herbicides and fungicides,

- **Do not apply later than recommended.**
- **Apply only those registered for the crop and pest.**
- **Do not apply more than the recommended amount.**
- **Do not apply more often than recommended on the label.**

When controlling insects, for example, do not apply an insecticide later than the recommended number of days from harvest. For example, Matador 120 EC 42–83 mL (3 days) indicates that the Matador spray should not be used later than 3 days before the beginning of harvest and that no more than 83 mL of an emulsifiable concentrate formulation containing 120 g/L of Matador should be used for 1 hectare of crop in an application.

Bee Poisoning

Honeybees, as well as other bees and insects, are important pollinators of several crops including alfalfa, canola, cucumbers, melons, pumpkins and squash. Corn, canola and legumes are also important pollen sources. It is therefore essential to refrain from poisoning any bees that are foraging on these crops.

Insecticides may be required for insect control. With careful management, good insect control can be achieved without killing bees. Spraying sweet corn for earworms and spraying broccoli fields when a portion of the field is in bloom are particularly sensitive cases. The following are a few points to remember in preventing bee poisoning.

1. Do not spray any flowering crop on which bees are foraging. If an insecticide application is necessary, spray in the early morning or in the evening when bees are not foraging. Bees usually do not forage at temperatures below 13°C.

2. If an insecticide poisonous to bees is required when they are foraging, notify neighbouring beekeepers so that they can protect their bees.

3. To prevent drift toward any nearby hives, do not apply insecticide on windy days.

4. Remember that ground applications are generally less hazardous than aircraft applications and usually produce less drift.

5. When there is a choice, choose the formulation less hazardous to bees. Dusts are more toxic than sprays. EC formulations are less toxic than WP formulations.

Most organophosphate and carbamate insecticides are highly toxic to bees. Insecticides used in vegetable crop production that are toxic to bees are listed in Table 1–2, *Relative Toxicity of Insecticides to Honeybees*, on page 9.

Other insecticides listed in this guide can be applied at any time with reasonable safety to bees.

When planning to apply a pesticide, advise local beekeepers so that they can move colonies out of the danger area. The Provincial Apiarist has a list of the beekeepers in your area.

Pest Control Product Packaging

To simplify disposal of empty pesticide packages, the industry introduced soluble packages that dissolve in the tank of the farm sprayer. Water-soluble packaging under names such as Clean Pak, Solupak, and Toss-N-Go is used for dry-flowable and wettable-powder formulations of pesticides.

In the majority of cases, the water-soluble packaging material is PVA (polyvinyl alcohol). This material dissolves completely when added to the water in the sprayer tank according to instructions.

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In the majority of cases, the water-soluble packaging material is PVA (polyvinyl alcohol). This material dissolves completely when added to the water in the sprayer tank according to instructions.

TABLE 1–2.
Relative Toxicity of Insecticides to Honeybees

GROUP 1 **Very toxic** **Do not apply to flowering crops or weeds.**	
Common name	**Trade name**
permethrin	Pounce
diazinon	DZN, Diazinon
fenvalerate	Belmark
dimethoate	Cygon, Lagon
naled	Dibrom
carbofuran	Furadan
azinphos-methyl	Guthion, APM, Sniper
phosmet	Imidan
methomyl	Lannate
chlorpyrifos	Lorsban, Pyrifos, Pyrinex
malathion	Malathion
methamidophos	Monitor
parathion	Parathion
cypermethrin	Ripcord, Cymbush
carbaryl	Sevin
GROUP 2 **Moderately toxic** **Apply only during late evenings or early morning.**[1]	
Common name	**Trade name**
deltamethrin	Decis
disulfoton	Di-syston
methoxychlor	Methoxychlor
pirimicarb	Pirimor
endosulfan	Thiodan, Thionex
GROUP 3 **Relatively non-toxic**	
Most of the fungicides and herbicides.	

[1] Unusually low temperatures at time of application may cause insecticides to remain toxic up to 20 times longer than during warm weather. High temperatures in the early morning or late evening may extend active foraging by bees.

Handling

- Do not allow water-soluble pouches to become wet prior to adding them to the sprayer tank.
- Do not handle the pouches with wet hands or wet gloves.
- Do not remove water-soluble pouches from the overwrap (outer package) except when adding them to the sprayer tank.
- Always reseal the outer package to protect the remaining pouches from moisture.

Mixing

- After spray tank is one-quarter full of water and the agitator is running, add the water-soluble pouches to the tank.
- Depending on the water temperature and the degree of agitation, these pouches dissolve completely within five minutes.
- As the tank continues to fill, add any other compatible pesticides.

Compatibility

- Do not add a pesticide that is incompatible with the PVA packaging material. The PVA material is not soluble with summer-type oils (e.g., Superior Oil).
- Do not combine any material containing boron (e.g., Solubor), chelated micronutrients or water-soluble fertilizers with the pouches. The combination is likely to cause a sticky, insoluble substance in the tank.
- After applying boron, chelated micronutrients or water-soluble fertilizers, completely empty and rinse the spray tank before using any product packaged in PVA.

Read all labels and instructions carefully. For more details, contact your pest control product supplier.

Pesticide Concentration

Brands of a pesticide from different companies often have different concentrations of the same chemical. When using a pesticide with a concentration different from that listed in this publication, adjust the rate of application so that the same amount of actual chemical (active ingredient) is applied. Read the label for correct dosages.

Seed Treatments

Seed dressings or treatments are poisonous to people and livestock. Do not inhale the fumes or dust when treating or handling treated seed. Wear neoprene or nitrile gloves. Wash all residue of these chemicals from your skin after finishing the treatment. Chemically treated seed is poisonous.

Never feed surplus seed to livestock. Destroy all the bags that have held treated seed as recommended in the section *Disposal of Pesticide Containers or Contaminated Material* on page 6.

Spray Tank Mixtures in Alkaline Water

With many pesticides susceptible to alkaline water, it is recommended that pesticides diluted with alkaline water be used immediately.

However, spraying immediately is not always possible owing to unexpected events such as rain, wind, sickness. Any lengthy delay in applying spray mixtures may result in pesticide activity loss due to degradation and possibly a corresponding decrease in pest control. The rate of degradation is dependent on the pesticide, the concentration of the pesticide in the tank (dilution factor) and the pH and temperature of the water.

To avoid this possibility, it is recommended that alkaline water be neutralized before adding any pesticides.

Compatibility of Spray Materials

For information on the compatibility of spray materials, always check the product label. Compatibility may refer to the physical or chemical compatibility of two products in solution. Physically incompatible combinations result in a physical change in the solution.

Components of the combined product may plug nozzles or become solidified or gummy in the tank. Chemical incompatibility can result in chemical changes in the spray solution that can lead to reduced efficacy or can cause plant injury when sprayed on the crops. The result of chemical incompatibility may not be evident until after the spray is applied.

The compatibility of two products may vary with the formulation of those products. For example, two products may be compatible as wettable powder (WP) formulations, but the same active ingredients may not be compatible as emulsifiable concentrate (EC) formulations.

Compatibility generally refers to two-way mixtures. Adding a third product to a tank mix, even if all are compatible with each other in two-way combinations, may result in further incompatibility.

The compatibility of some materials may depend on the solvents and emulsifiers used by the manufacturer. ECs are more likely to cause compatibility problems than WPs. If WPs are mixed with ECs, incompatibility may result.

Consult your supplier or the pest control product manufacturer before mixing products.

Special Notes

- *Mixing pesticides with foliar fertilizers is not recommended.*
- *Fixed copper is generally not compatible with organophosphate insecticides.*

2. Pest Management

Integrated Pest Management (IPM)

For purposes of this publication, pests are considered to be insects, diseases, nematodes, animals and weeds.

A variety of methods are available for controlling different pests, however, there is no substitute for regular and consistent crop monitoring and the use of established thresholds to assist the decision-making process. Serious crop losses can often be prevented by using all the available management strategies (cultural, biological, mechanical, genetic and chemical) to better manage pest problems. When treatments are necessary, apply them at the correct time and stage of pest development. Degree-day models and disease forecasting models are also helpful. Also consider other factors that affect pest levels and development, such as soil fertility, irrigation, varieties, climate, crop nutrition and marketing, as part of an integrated crop management program.

To reduce the development of resistance to pest control products, rotate between pesticide groups. In the following text, the group for each recommended pest control product is noted.

Seed Treatment

Damage from some diseases and insects can be prevented by using chemical seed treatments, hot-water treatments or soil fumigants.

Warning

The concentration of pesticides in seed treatments is high, so the products are quite toxic. Wear rubber gloves, full protective clothing and a respirator when treating seed. Avoid skin contact and inhaling fumes. Do not handle treated seed with bare hands. Dispose of surplus treated seed by burying it under 50 cm of soil in an area away from water supplies.

Chemical Seed Treatment

All vegetable seed should be treated with a fungicide to help prevent seed decay and damping-off.

To control black rot in cabbage, cauliflower, Brussels sprouts, broccoli and rutabaga, treat the seed with streptomycin (antibiotic group). Check the label for the best method of treating the seed and the best rates to use. See Table 2–1, *Registered Seed Treatments for Vegetables*, on page 12, for more information.

Hot-Water Treatment

Buy hot-water treated seed or treat seed as follows:

1. Place seed in a large cheesecloth bag; the bag should not be more than half full. Place bags of seed in a large container filled with warm water.

2. Stir the water and bags of seed continually to secure rapid penetration of heat to maintain uniform temperature in the seed lot. Be sure to use an accurate thermometer.

Cabbage, broccoli, Brussels sprouts, tomato, pepper and eggplant

Soak seed for 25 minutes in water maintained at 50°C. Spread seed out to dry.

Cauliflower, kohlrabi, kale and summer turnip

Treat seed as above but for 15 minutes.

Celery

Treat seed at 48°C for 30 minutes.

Tomato

Tomato seed can be treated at 54°C for 25 minutes but must be planted within a few days. Tomato seed can be treated by soaking dry seed in 3 parts of 0.6 Molar hydrochloric acid (i.e., mix 1 part acid with 19 parts of distilled water) for 1 hr with frequent agitation. Drain the acid, thoroughly rinse in distilled water and dry. A 0.1 Molar hydrochloric acid (available from scientific supply companies) can also be used to soak the seeds for 1 hr with frequent agitation and, in this case, the seeds can be dried without rinsing in water.

Spray Tank Mixtures in Alkaline Water

With many pesticides susceptible to alkaline water, it is recommended that pesticides diluted with alkaline water be used immediately.

However, spraying immediately is not always possible owing to unexpected events such as rain, wind, sickness. Any lengthy delay in applying spray mixtures may result in pesticide activity loss due to degradation and possibly a corresponding decrease in pest control. The rate of degradation is dependent on the pesticide, the concentration of the pesticide in the tank (dilution factor) and the pH and temperature of the water.

To avoid this possibility, it is recommended that alkaline water be neutralized before adding any pesticides.

Compatibility of Spray Materials

For information on the compatibility of spray materials, always check the product label. Compatibility may refer to the physical or chemical compatibility of two products in solution. Physically incompatible combinations result in a physical change in the solution.

Components of the combined product may plug nozzles or become solidified or gummy in the tank. Chemical incompatibility can result in chemical changes in the spray solution that can lead to reduced efficacy or can cause plant injury when sprayed on the crops. The result of chemical incompatibility may not be evident until after the spray is applied.

The compatibility of two products may vary with the formulation of those products. For example, two products may be compatible as wettable powder (WP) formulations, but the same active ingredients may not be compatible as emulsifiable concentrate (EC) formulations.

Compatibility generally refers to two-way mixtures. Adding a third product to a tank mix, even if all are compatible with each other in two-way combinations, may result in further incompatibility.

The compatibility of some materials may depend on the solvents and emulsifiers used by the manufacturer. ECs are more likely to cause compatibility problems than WPs. If WPs are mixed with ECs, incompatibility may result.

Consult your supplier or the pest control product manufacturer before mixing products.

Special Notes

- *Mixing pesticides with foliar fertilizers is not recommended.*
- *Fixed copper is generally not compatible with organophosphate insecticides.*

2. Pest Management

Integrated Pest Management (IPM)

For purposes of this publication, pests are considered to be insects, diseases, nematodes, animals and weeds.

A variety of methods are available for controlling different pests, however, there is no substitute for regular and consistent crop monitoring and the use of established thresholds to assist the decision-making process. Serious crop losses can often be prevented by using all the available management strategies (cultural, biological, mechanical, genetic and chemical) to better manage pest problems. When treatments are necessary, apply them at the correct time and stage of pest development. Degree-day models and disease forecasting models are also helpful. Also consider other factors that affect pest levels and development, such as soil fertility, irrigation, varieties, climate, crop nutrition and marketing, as part of an integrated crop management program.

To reduce the development of resistance to pest control products, rotate between pesticide groups. In the following text, the group for each recommended pest control product is noted.

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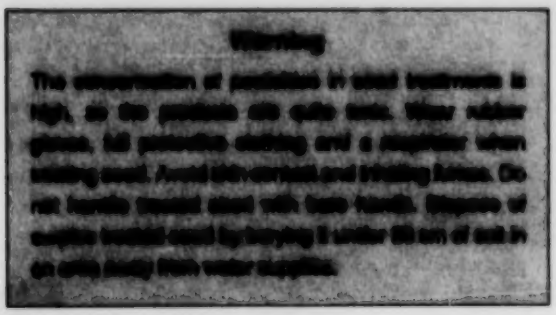

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Cabbage, broccoli, Brussels sprouts, tomato, pepper and eggplant

Soak seed for 25 minutes in water maintained at 50°C. Spread seed out to dry.

Cauliflower, kohlrabi, kale and summer turnip

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TABLE 2–1.

Registered Seed Treatments for Vegetables

Vegetable seeds should be treated with a fungicide to help prevent seed decay and damping-off. Always check the label for treatment methods and correct treatment rates. To avoid insecticide injury to seed, apply insecticides only in combination with a fungicide. Although commercial seed-treating equipment gives the best coverage, seed may be treated on the farm. Consult individual labels for instructions and safety precautions.

Trade Name	Active Ingredient(s)	Labeled Vegetable Crops	Pest(s)
Agrox B-3	diazinon-lindane-captan	lima and snap beans, sweet corn, peas	seed and root maggots, wireworms, seed rots & damping-off
Agrox D-L Plus	diazinon-lindane-captan	same as above	same as above
Apron XL-LS	metalaxyl-m	carrots, beets, spinach (export only), green, kidney, lima, navy, pole, snap, string and wax beans, peas	pythium damping-off and early season phytophthora root rot on beans and peas
Captan Flowable	captan	lima and snap beans, peas, sweet corn	seed decay, root rot, damping-off
Captan 30-Methoxychlor 3	captan-methoxychlor	beans, sweet corn	storage rots & insects, damping-off, seedling decay
DCT	diazinon-captan-thiophanate-methyl	sweet corn	root maggots, *Penicillium* species
Governor 75 WP	cyromazine	dry & green onions (imported seed only)	onion maggot
Maxim 480 FS	fludioxonil	sweet corn	seed decay, damping-off, seedling blights
Pro-Gro	carbathiin-thiram	onions	smut
Rovral WP	iprodione	carrots (imported seed only)	seed-borne *Alternaria*
Streptomycin 17	streptomycin sulfate	Brussels sprouts, cabbage, cauliflower, broccoli, rutabaga	bacterial black rot
Thiram 75 WP	thiram	beets, broccoli, Brussels sprouts, cabbage, cauliflower, celery, cantelope, cucumber, eggplant, lettuce, onions, peas, pepper, pumpkin, radish, snap beans, spinach, squash, sweet corn, tomato, turnip	damping-off, seedling blight, seed decay
Vitavax RS flowable	carbathiin-thiram-lindane	cabbage, cauliflower, broccoli, Brussels sprouts, rutabaga	damping-off, seed decay, flea beetles
Lindane ST	lindane	beans, peas, corn, cucumbers	wireworms
DLC Drillbox ST	diazinon-lindane-captan	corn, beans, peas	seed corn maggot, wireworms, seed rot

Damping-Off of Seedlings

Seedlings affected by damping-off rot at ground level and topple over. The damping-off fungus may cause seed decay also.

Steam or fumigate used flats and soil for growing seedlings (consult OMAFRA Publication 371, *Growing Greenhouse Vegetables*). Treat seeds with a protectant fungicide (also see the section *Chemical Seed Treatment* on page 11). Bench tops or other surfaces used to accommodate seedling flats should be sterilized with steam, formaldehyde or other effective disinfectants; alternatively, cover bench tops with clean plastic sheeting.

Water seedlings only when necessary and preferably before noon. Provide good ventilation and keep humidity low. If damping-off appears, water flats at a rate of 5 L/m^2, 2 or 3 times, at 4-day intervals, with oxine benzoate, ferbam or thiram (all in the dithiocarbamate group). Follow the manufacturer's label directions regarding concentration.

Where steam is used to treat soil, maintain a temperature not less than 82°C for 20 minutes throughout the soil. Avoid prolonged steaming.

Carefully follow the manufacturer's directions for the use of soil fumigants. You must have a permit to apply methyl bromide.

A permit may be obtained from the Pesticides Control Section, Ministry of the Environment, 135 St. Clair Ave. W., Toronto, M4V 1P5, Telephone (416) 323-5095.

In time, treated soils become recontaminated by damping-off fungi. This can be delayed in flats of pepper and Spanish onion seedlings by treating the steamed soil with Thiram 75 WP, 5 g to a flat of soil, or 800 g/100 m^2 of bed. Thiram (dithiocarbamate group) must be mixed thoroughly with the soil to a depth of 8 cm.

Disinfect used flats with steam or immerse moistened flats in a solution of 5 L of 37% formaldehyde in 125 L water, then set flats aside until the smell of formaldehyde disappears.

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Captan 30-Methoxychlor 3	captan-methoxychlor	beans, sweet corn	storage rots & insects, damping-off, seedling decay
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Vitavax RS flowable	carbathiin-thiram-lindane	cabbage, cauliflower, broccoli, Brussels sprouts, rutabega	damping-off, seed decay, flea beetles
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Disinfect used flats with steam or immerse moistened flats in a solution of 5 L of 37% formaldehyde in 125 L water, then set flats aside until the smell of formaldehyde disappears.

Bacterial Diseases

Bacteria are microscopic organisms that cause significant damage to vegetable crops. Bacterial blight in beans, black rot in cole crops, angular leaf spot and bacterial wilt in vine crops, bacterial spot in peppers, blackleg in potatoes and bacterial speck, spot and canker in field tomatoes are examples.

Bacteria spread passively, for example, through splashing water, violent wind storms, insects such as the cucumber beetle, animals (including humans) and machinery moving through wet fields — especially when the foliage is wet, such as in the morning under heavy dew conditions.

Infected seeds are the primary source of bacterial disease introductions. Even as few as 1 in 30,000 infected seeds, a level often beyond the detection ability of most laboratories, is enough to cause disease outbreaks. Bacteria can also survive for short periods of time on crop debris in the soil, on benches, trays, etc.

The increase of local vegetable transplant production has altered the occurrence and lessened the severity of some bacterial diseases in Ontario. Transplants grown in the southern United States, especially crops such as tomatoes were often clipped. This process allowed the bacteria to get into the vascular tissue during shipment. This resulted in severely stunted plants, many of which died in Ontario fields. With local transplants, the risk of the seed-borne diseases is the same now as before. However, due to the reduced potential of spreading within a greenhouse, fewer diseased plants are sent to the field. Although fewer plants die in the field, the disease does appear as a foliar blight, similar in appearance to some foliar fungal diseases.

Control of bacterial diseases has been based for many years on seed treatments. Fermentation, hot water, chlorine and hydrochloric acid treatments have been tried on different seed types. Even under the most rigid treatment protocols, a small portion of diseased seed can still lead to significant problems in the field.

Many cultural and chemical control methods have been used with varying success. Greenhouse sanitation and water management along with a regular spray program with copper (inorganic group) and mancozeb (dithiocarbamate group) mixtures have proven successful.

The use of copper and mancozeb as a foliar bactericide spray in the field has not proven entirely successful; however, they are the only spray products that are registered. Control can only be achieved when copper and mancozeb are applied early, even before symptoms appear. During extended wet periods, control of foliar bacterial diseases is difficult if the disease has become established.

New bacterial management techniques such as the reduction of bacterial spread across fields by using rye cover crop strips as wind barriers are being evaluated.

Clean seed, clean transplants, new, resistant cultivars, appropriate spray programs, limiting the spread within fields by only working in the field when the foliage is dry, reducing stress, and increasing soil fertility when bacterial diseases are detected, all play a role in successfully managing bacterial diseases.

Crop Rotation for Control of Diseases

Crop rotation can be an important method of controlling some diseases caused by fungi, bacteria and nematodes. Rotation is effective when the organism causing the disease can only survive on the refuse and undecomposed plant matter of susceptible varieties in the soil. Rotation with a non-susceptible crop for 2–3 years usually allows enough time for plant material in the soil to completely decompose. In the absence of susceptible plant material, these organisms die off. This type of rotation works only when successive crops are not susceptible hosts. It is important to remember that plants in the same family (for example, potatoes, tomatoes, peppers and eggplant) may all be susceptible to the same disease organisms. Do not rotate with plants in the same family.

Anthracnose disease of snap beans is one example of the importance of rotation. The anthracnose fungus can only survive in the soil until the bean plant tissue has decomposed. Two years of non-host crops will "starve out" the organism. The fungus can survive on bean trash and straw, which should not be spread on fields intended for snap beans within the next 2–3 years.

Crop rotation is also effective against corky root rot of lettuce, black rot of crucifers, root rot, wilt and near wilt of peas.

Crop rotation is not a practical disease management method for persistent soilborne diseases such as onion smut (10–12 years) and cabbage yellows (10 years).

Some disease organisms such as *Fusarium, Verticillium* and *Sclerotinia* survive for long periods of time in soil. Crop rotation will eventually reduce the soil population levels of these persistent disease organisms but will not eliminate them.

Diseases that are spread by wind or by insects are generally not controlled by rotation. Many leafblight organisms and powdery mildew fungi can blow into fields from neighbouring weeds and fields that are infested. Virus diseases that are spread by aphids, bacterial wilt of cucumbers spread by the cucumber beetle and aster yellows, which is spread by leafhoppers, cannot be controlled by rotation. Resistant varieties, seed treatments and other methods may be used to manage these diseases.

When considering rotation as a means of disease control, check with a crop specialist to make sure that it will be effective for the problem.

Spraying Vegetable Crops

Crop Monitoring and Scouting

The decision to apply any pest control product should be based upon regular and consistent crop monitoring information. Scouting your crops helps to detect insects, diseases, nematodes, weeds and physiological disorders before they become field epidemics. Be sure the problem is correctly identified and that the level of the pest warrants a treatment. If a pest control product is required, follow the following guidelines.

Water Volume

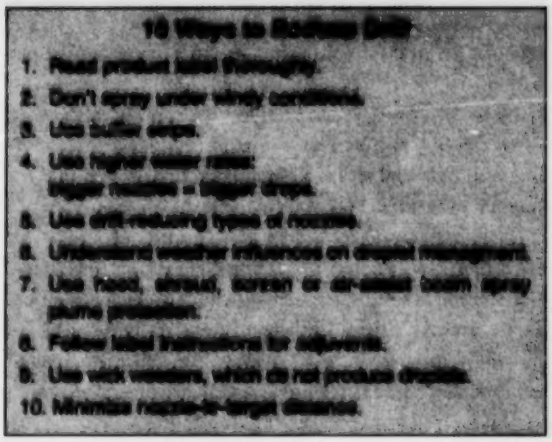
Generally, most insecticides/fungicides are applied with about 135–450 L/ha (54–180 L/ac). Herbicide applications range from 55–350 L/ha (22–140 L/ac).

Pressure

For herbicide applications, spray pressures can reach from 130–300 kPa for standard flat fan orifice tips. To reduce the chance of drift, manufacturers offer drift-reducing tips that deliver the same amount of liquid but produce a coarser spray. For fungicides and insecticides, pressures of between 550–1,000 kPa are commonly used and associated with hollow, cone-type nozzles.

Air Temperature and Relative Humidity

Pesticides, especially insecticides, can cause phytotoxicity or burning of plant foliage/flowers if applied during very hot weather (above 27°C). Avoid applications between 10:00 AM and 2:00 PM, as plants will be more prone to injury. The water droplets themselves can, at times, act as tiny magnifying glasses and cause plant injury. A large portion of the spray droplets may also evaporate before they hit the target due to hot, dry air.



During conditions of high relative humidity, the drying of spray materials will be delayed. Prolonged and slow drying of pesticides can lead to phytotoxicity in some instances.

Also note that "synthetic pyrethroid"-type insecticides (Ripcord, Cymbush, Pounce, Matador, etc.) break down quickly when temperatures are above 27°C, reducing their effectiveness. If possible, apply other materials or apply these in the evening when temperatures have dropped.

Wind Speed & Drift

When applying fungicides and insecticides, moderate air movement helps move the product in and around the crop. Optimum air movement is 3–8 km/hr. In addition, light winds will help in the drying process.

On the other hand, a crosswind can concentrate what is meant to be a 50-cm band into a 25-cm band, thereby increasing the application rate on the sprayed area.

To prevent unwanted drift, avoid spraying when the wind speed is more than 16 km/hr. Drift is also possible at lower wind speeds. Drift potential is affected by the interaction of travel speed, wind speed and droplet size.

Some herbicides can drift for up to 6 km, and plants such as grapes, beans, peppers and tomatoes are particularly sensitive to dicamba, glyphosate and 2,4-D injury. Minimizing drift will be especially important for volatile products such as dicamba and 2,4-D. Use the amine formulation of 2,4-D, as it is less volatile than the ester formulation.

When applying herbicides, drift can be minimized by:

- using larger droplet sizes
- not applying during very hot and dry weather (temperatures in excess of 27°C) when spray material can readily volatilize

Rainfall

The decision to spray just prior to a rain or shortly after should be based on a matter of plant protection. This may be more critical when applying fungicides. Once they have dried, most fungicides can withstand about 2.5 cm of rainfall and still provide adequate protection. However, after an additional 2.5 cm of rain, spray the crop with an additional application of spray material.

Waiting for the rain to stop before the initial application may allow disease organisms to invade plant tissue unimpeded by protective sprays.

When applying pre-emergent products, herbicides are best applied before a rain so as to wash them into the zone of seed germination and to activate their chemistry. Otherwise, post-emergent applications are best applied after a rain or at least allowed to dry adequately prior to rainfall.

Type of Nozzles

Applying herbicides with flat-fan nozzle tips provides uniform distribution of spray solution with boom-type sprayers.

Hollow cones are generally used to apply fungicides or insecticides. This type of nozzle generally produces a finer and more uniform spray than solid cone nozzles. Hollow cones are particularly suited to the application of wettable powders, flowables and suspensions. Solid cones are used when increased penetration into the crop canopy is required.

Recommendations listed in this publication are on a per hectare basis. Therefore, if herbicides or other pesticides are banded, the contents of the spray tank will cover more acreage although the rate of product application will stay the same.

Rates of Application

When banding a herbicide or drenching an insecticide versus an overall spray, remember that the amount of pesticide and rate of pesticide are two very different things. The rate of product per area will remain the same, however, the total amount of product used must be reduced accordingly on a per-area basis depending upon the width of the band.

Keep in mind that if the tractor-sprayer speed is calibrated at 6 km/hr for the proper delivery of pesticide, but the speed is reduced to 3 km/hr at the end of the row, all else being equal, there will be double the rate of product being applied at the end of the row.

CAUTION!

Spray drift can damage or destroy susceptible crops and shrubs at a great distance from the sprayer. Do not use 2,4-D-type herbicides near susceptible crops such as grapes, beans, tomatoes or tobacco. Take into consideration both the direction and speed of the wind when applying this type of herbicide. Use low pressure whenever possible (200–250 kPa is usually enough). Use a separate sprayer to apply 2,4-D and similar herbicides. Drain and wash out the sprayer immediately after use. Unless recommended by competent authorities, do not mix different herbicides together. Similarly, do not mix herbicides with other pesticides, foliar fertilizers, surfactants or detergents.

Calibration and Maintenance

The recommendations above are very much dependent upon the proper application of products. Therefore, it is critical that spray equipment be calibrated regularly to ensure that the proper amounts of product are being delivered. The importance of careful and routine maintenance of sprayers cannot be over-emphasized.

Weed Management

Good cultural practices should always be the first line of defence for weed control. The grower can reduce the spread and decrease the number of weed seeds by cutting or disking weeds before they go to seed. Concentrate on the eradication of persistent perennial weeds by cultural practices. Thorough working of the land prior to seeding or planting will kill many recently germinated weeds. Careful, shallow cultivation is best.

Chemical weed control should never be a substitute for good cultural practices. Use chemical weed killers wherever practical as a supplement to good cultural practices.

It is very important to apply the correct dosage when using these chemicals. Herbicides can cause severe injury to the crop if more than the recommended rate is used.

Do not experiment with chemicals or mixtures that are not recommended. If more than a permitted amount of pesticide residue is found in the crop, the entire crop can be seized by provincial or federal authorities without compensation to the grower.

For specific chemical weed control recommendations, see Chapter 6, *Weed Management for Vegetables* on page 141.

Diseases that are spread by wind or by insects are generally not controlled by rotation. Many leaf blight organisms and powdery mildew fungi can blow into fields from neighbouring weeds and fields that are infested. Virus diseases that are spread by aphids, bacterial wilt of cucumbers spread by the cucumber beetle and aster yellows, which is spread by leafhoppers, cannot be controlled by rotation. Resistant varieties, seed treatments and other methods may be used to manage these diseases.

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Pesticides, especially insecticides, can cause phytotoxicity or burning of plant foliage/flowers if applied during very hot weather (above 27°C). Avoid applications between 10:00 AM and 2:00 PM, as plants will be more prone to injury. The water droplets themselves can, at times, act as tiny magnifying glasses and cause plant injury. A large portion of the spray droplets may also evaporate before they hit the target due to hot, dry air.

10 Ways to Reduce Drift

1. Read product label thoroughly.
2. Don't spray under windy conditions.
3. Use buffer strips.
4. Use higher water rates:
   bigger nozzles = bigger drops.
5. Use drift-reducing types of nozzles.
6. Understand weather influences on droplet managment.
7. Use hood, shroud, screen or air-assist boom spray plume protection.
8. Follow label instructions for adjuvants.
9. Use wick weeders, which do not produce droplets.
10. Minimize nozzle-to-target distance.

During conditions of high relative humidity, the drying of spray materials will be delayed. Prolonged and slow drying of pesticides can lead to phytotoxicity in some instances.

Also note that "synthetic pyrethroid"-type insecticides (Ripcord, Cymbush, Pounce, Matador, etc.) break down quickly when temperatures are above 27°C, reducing their effectiveness. If possible, apply other materials or apply these in the evening when temperatures have dropped.

Wind Speed & Drift

When applying fungicides and insecticides, moderate air movement helps move the product in and around the crop. Optimum air movement is 3–8 km/hr. In addition, light winds will help in the drying process.

On the other hand, a crosswind can concentrate what is meant to be a 50-cm band into a 25-cm band, thereby increasing the application rate on the sprayed area.

To prevent unwanted drift, avoid spraying when the wind speed is more than 16 km/hr. Drift is also possible at lower wind speeds. Drift potential is affected by the interaction of travel speed, wind speed and droplet size.

Some herbicides can drift for up to 6 km, and plants such as grapes, beans, peppers and tomatoes are particularly sensitive to dicamba, glyphosate and 2,4-D injury. Minimizing drift will be especially important for volatile products such as dicamba and 2,4-D. Use the amine formulation of 2,4-D, as it is less volatile than the ester formulation.

When applying herbicides, drift can be minimized by:

- using larger droplet sizes
- not applying during very hot and dry weather (temperatures in excess of 27°C) when spray material can readily volatilize

Rainfall

The decision to spray just prior to a rain or shortly after should be based on a matter of plant protection. This may be more critical when applying fungicides. Once they have dried, most fungicides can withstand about 2.5 cm of rainfall and still provide adequate protection. However, after an additional 2.5 cm of rain, spray the crop with an additional application of spray material.

Waiting for the rain to stop before the initial application may allow disease organisms to invade plant tissue unimpeded by protective sprays.

When applying pre-emergent products, herbicides are best applied before a rain so as to wash them into the zone of seed germination and to activate their chemistry. Otherwise, post-emergent applications are best applied after a rain or at least allowed to dry adequately prior to rainfall.

Type of Nozzles

Applying herbicides with flat-fan nozzle tips provides uniform distribution of spray solution with boom-type sprayers.

Hollow cones are generally used to apply fungicides or insecticides. This type of nozzle generally produces a finer and more uniform spray than solid cone nozzles. Hollow cones are particularly suited to the application of wettable powders, flowables and suspensions. Solid cones are used when increased penetration into the crop canopy is required.

Recommendations listed in this publication are on a per hectare basis. Therefore, if herbicides or other pesticides are banded, the contents of the spray tank will cover more acreage although the rate of product application will stay the same.

Rates of Application

When banding a herbicide or drenching an insecticide versus an overall spray, remember that the amount of pesticide and rate of pesticide are two very different things. The rate of product per area will remain the same, however, the total amount of product used must be reduced accordingly on a per-area basis depending upon the width of the band.

Keep in mind that if the tractor-sprayer speed is calibrated at 6 km/hr for the proper delivery of pesticide, but the speed is reduced to 3 km/hr at the end of the row, all else being equal, there will be double the rate of product being applied at the end of the row.

CAUTION!

Spray drift can damage or destroy susceptible crops and shrubs at a great distance from the sprayer. Do not use 2,4-D-type herbicides near susceptible crops such as grapes, beans, tomatoes or tobacco. Take into consideration both the direction and speed of the wind when applying this type of herbicide. Use low pressure whenever possible (200–250 kPa is usually enough). Use a separate sprayer to apply 2,4-D and similar herbicides. Drain and wash out the sprayer immediately after use. Unless recommended by competent authorities, do not mix different herbicides together. Similarly, do not mix herbicides with other pesticides, foliar fertilizers, surfactants or detergents.

Calibration and Maintenance

The recommendations above are very much dependent upon the proper application of products. Therefore, it is critical that spray equipment be calibrated regularly to ensure that the proper amounts of product are being delivered. The importance of careful and routine maintenance of sprayers cannot be over-emphasized.

Weed Management

Good cultural practices should always be the first line of defence for weed control. The grower can reduce the spread and decrease the number of weed seeds by cutting or disking weeds before they go to seed. Concentrate on the eradication of persistent perennial weeds by cultural practices. Thorough working of the land prior to seeding or planting will kill many recently germinated weeds. Careful, shallow cultivation is best.

Chemical weed control should never be a substitute for good cultural practices. Use chemical weed killers wherever practical as a supplement to good cultural practices.

It is very important to apply the correct dosage when using these chemicals. Herbicides can cause severe injury to the crop if more than the recommended rate is used.

Do not experiment with chemicals or mixtures that are not recommended. If more than a permitted amount of pesticide residue is found in the crop, the entire crop can be seized by provincial or federal authorities without compensation to the grower.

For specific chemical weed control recommendations, see Chapter 6, *Weed Management for Vegetables* on page 141.

TABLE 2–2.
Cutworm Treatments

Product	Group	Rate	Days to Harvest/ Stage of Growth	Crop
Lannate SP[1,2]	carbamate	270–540 g/ha	3 days	potato
		270–540 g/ha	1 day	tomato
Lorsban 4E Pyrinex 480 EC	organophosphate	1.2–2.4 L/ha	32 days	broccoli, Brussels sprout, cabbage, cauliflower, Chinese cabbage
		2.4–4.8 L/ha	60 days	bulb onion, carrots
		1.2–2.4 L/ha	70 days	celery, sweet corn, tomato
		1.2–2.4 L/ha	60 days	cucumber
		1.2–2.4 L/ha	50 days	garlic
		1.2–2.4 L/ha	40 days	green pepper
		1.2–2.4 L/ha	7 days	potato
		1.2–2.4 L/ha	30 days	rutabaga
Matador 120 EC[1,2]	pyrethroid	83 mL/ha	3 days	head lettuce
		83 mL/ha	up to 5 leaves	sweet corn, tomato
Orthene 75 SP	organophosphate	1.2 kg/ha	90 days	tomato (Transplant water only.)
Pounce 384 EC[2]	pyrethroid	180 ml/ha	2 days	asparagus
		180–390 ml/ha	up to 5 leaves	beets, carrots, lettuce, onion, pea, sweet corn
		180–390 ml/ha	7 days	broccoli
		180–390 ml/ha	3 days	Brussels sprout, cabbage, cauliflower
		180–390 ml/ha	1 day	pepper, potato
		180–260 ml/ha	1 day	tomato
Ripcord 400EC	pyrethroid	175 ml/ha	21 days	carrot, cole crops, lettuce, onions, sweet corn
		175 ml/ha	7 days	potato
Sevin XLR Plus (Late season climbing cutworms only.)	carbamate	2.5–6.4 L/ha	2 days	asparagus
		2.25 L/ha	5 days	cucumber, melon, pumpkin, squash
		5.25 L/ha	1 day	sweet corn

[1] Minimum period before re-entry is 24 hours.
[2] The higher label rates are recommended for crops grown on muck soils, under dry conditions or if cutworms are large. Do not disturb the soil surface for 5 days after treatment. Check the label.

General Pests

There are a number of pests that attack a wide range of crops. Vertebrate pests (such as deer, rabbits and groundhogs), cutworms, wireworms and slugs may be found periodically. Monitor crops closely to determine the type and level of the problem, then use a variety of methods, where available, to reduce damage to the crop.

Cutworms

Several species of cutworms attack vegetables. Dark-sided, redbacked, black and glassy cutworms appear early in the growing season. Depending on soil and climatic conditions, these species will attack the plants below or at the soil surface, or will feed on the foliage. Late-season damage is caused primarily by the variegated cutworm, which is a foliage feeder.

Effective cutworm control is dependent on proper timing of insecticide applications under favourable soil and climatic conditions. The insecticides recommended for use are short-residual and breakdown quickly in sunlight. See Table 2–2, *Cutworm Treatments*, above.

Most species of cutworms go into the soil during the day and come out to feed at night. Insecticide applications should be made in late afternoon or early evening when temperatures are lower, just before the insects come up to feed. Insecticides are more effective on moist soil than on dry soil.

Note: The insecticides recommended are not registered on all crops. Consult the label to determine registration on specific crops, the preferred methods and rates of application and the required interval between application and harvest.

Early-Season Species of Cutworms

See Table 2–3, *Notes on Chemicals for Early-Season Species of Cutworms,* on page 17, for control recommendations.

Late-Season Species of Cutworms

When cutworm damage first appears, apply carbaryl, methomyl (both of the carbamate group) or permethrin (pyrethroid group) in sufficient water for good coverage of foliage. If using methomyl, note that the minimum period for re-entry is 24 hours. For good cutworm control, it is essential to penetrate the foliage canopy with the spray. For best control, spray when cutworm larvae are small.

TABLE 2–3.
Notes on Chemicals for Early-Season Species of Cutworms

Active Ingredient	Group	Trade Name(s)	Notes
Pre-planting cover-crop treatment[1]			
chlorpyrifos	organophosphate	Lorsban 4E Pyrinex 480 EC	Apply 5 days before plowing under the rye or wheat cover crop, when it is 10–15 cm high. Apply once, in 200–400 L of water/ha. Also apply to fencerows and to a 15-m strip of any nearby cover crop.
Pre-planting soil treatment[1]			
chlorpyrifos	organophosphate	Lorsban 4E Pyrinex 480 EC	Apply once, in 200–400 L of water/ha, as a broadcast soil-surface application. Do not incorporate on muck soils.
Post-planting soil treatment			
chlorpyrifos	organophosphate	Lorsban 4E Pyrinex 480 EC	Effective only on surface-feeding stages of cutworms. Registered only for use on seedlings (up to 5-leaf stage) and/or transplants. Chlorpyrifos may be phytotoxic to some varieties of plants under stress conditions, i.e., hot, dry weather or cool, excessively wet weather.
permethrin	pyrethroid	Pounce 384 EC	Use higher rates on dry mineral soils and muck soils and when cutworms are large (2.5–4.0 cm long). Effective only on surface-feeding stages of cutworms. Registered only for use on seedlings (up to 5-leaf stage) and/or transplants.
cypermethrin	pyrethroid	Ripcord 400 EC	Use sufficient water for good coverage (200–500L/ha). Do not disturb the soil for at least 5 days after treatment. Effective only on surface-feeding stages of cutworms. Registered only for use on seedlings (up to 5-leaf stage) and/or transplants.
cyhalothrin-lambda	pyrethroid	Matador 120 EC	Use sufficient water for good coverage (200–500L/ha). Do not disturb the soil for at least 5 days after treatment. Effective only on surface-feeding stages of cutworms. Registered only for use on seedlings (up to 5-leaf stage) and/or transplants.

[1] Where there has been a history of cutworm damage, either pre-planting treatment method is preferred. Pre-planting treatments will not be phytotoxic to vegetable crops.

Wireworms

Wireworms are more likely to be a problem for the first 2 years following sod. Controlling wireworms is difficult and may take several growing seasons. Crop rotation and exposing the soil to freezing and thawing conditions may be helpful.

Seed Treatment

For large-seeded vegetables (beans, peas, etc.), use a lindane (polychlorocycloalkane group) seed treatment. See Table 2–1, *Registered Seed Treatments for Vegetables*, on page 12.

Treatment for Tomatoes

For tomatoes, use acephate (organophosphate group) Orthene 75 SP 1.2 kg in 2,000 L water.

Note: This product is for tomatoes only and should only be used as a transplant water treatment.

Slugs

Metaldehyde is specific for slug control. Most other chemicals have little effect on them. Slug baits, dusts and sprays containing metaldehyde are registered for use in Canada, but the slug bait appears to be the only one widely distributed in Ontario.

White Grubs

To avoid injury by white grubs, wait 2 or more years before planting vegetables on land that had been planted with grass sod.

Nematodes

Root-lesion, root-knot and sugar beet cyst nematodes are responsible for most nematode problems in Ontario vegetable crops. A crop may be attacked by the combined action of two or more kinds of nematodes. In some cases, nematodes aggravate diseases caused by fungi (for example, root-lesion nematodes worsen *Verticillium* wilt of eggplants, tomatoes and potatoes). In potatoes, the *Verticillium*-nematode complex is involved in the potato early dying problem.

The Root-Lesion Nematode

Common in Ontario, this nematode has a very wide host range that includes most vegetables, strawberries, corn, legumes and tobacco. It causes tiny, brownish, scratch-like wounds on the roots and is very destructive to such crops as celery and lettuce.

The Root-Knot Nematode

Frequently found in vegetable-producing areas, particularly in muck soils and greenhouses, these nematodes cause galls on the roots, resulting in poor plant growth that quite often shows up as patchy areas in a field. Many

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crops are attacked by this nematode, sometimes resulting in severe losses, particularly with carrots. The Southern root knot species may be imported on transplants.

The Sugar Beet Cyst Nematode

This nematode is quite destructive to table beets and spinach, but other root and cruciferous crops are also affected. It is frequently found in association with rhubarb. This nematode can be seen on the roots as tiny, white or brown, pearl-shaped objects.

The Bulb and Stem Nematode

Several races of this nematode have been identified in other parts of the world. Many races are host-specific, while others infect many hosts. The races that infect carrots have not been found in Ontario.

This nematode causes onion bloat and has been found in several of the onion-growing areas. Onion bloat symptoms may appear early in the crop when leaves become twisted and deformed. Infected plants that survive are usually deformed, with shorter, thickened leaves. Splitting and cracking of infected bulbs is one of the most easily recognizable symptoms.

Practical control measures depend largely on the limited host range of the Ontario population of this nematode as well as sanitation, soil fumigation and crop rotation.

Note

Before deciding upon a management strategy for nematodes, a nematode soil test must be completed to correctly identify the type and level of nematode that may be present. Consideration of past, present and future crops should be included.

Steam pasteurization of greenhouse soil is still a very effective means of controlling nematodes, although chemical fumigation has become a common practice with many growers. An integrated approach combining crop rotation, nematode-suppressing cover crops, cultivation practices and fumigation is recommended.

The chemicals most commonly used in preplant soil fumigation for nematode control are Busan 1020, Telone II, Telone C-17, Vapam and Vorlex Plus. In Ontario, much of the soil fumigation against nematodes is done by custom operators. Fumigants are either broadcast applied, banded in beds or injected into soil, depending on the nematode problem, soil type and chemical used. Muck soils often require higher rates. Always follow the label carefully regarding rates and application method.

Shank-injection of fumigants is preferable to reduce the chance of wind-and-odour drift, runoff or other mishaps.

Soil can be fumigated either in the fall or in the spring.

At the time of fumigation, the soil temperature should be at least 4°C at the 15-cm depth, the soil must be thoroughly worked to a depth of 20–25 cm and the moisture content of the soil must be at a level that would permit good seed germination. With fall applications, the soil should be worked several weeks before fumigation so that the area is reasonably free from undecomposed crop residue. For more information, refer to the OMAFRA Factsheet, *Land Preparation — A Key to Successful Soil Fumigation*, Order No. 89-177.

Before planting, till the soil thoroughly to aerate and ensure that all traces of fumigant odour have dissipated. With fall applications, the soil should not be disturbed after sealing until the normal spring cultural operations are started. Growers should wait at least 2 weeks before planting into spring-fumigated soil.

Methyl bromide and high rates of Vapam, Busan and Vorlex Plus are used as general-purpose soil fumigants. Do not use nematicides containing bromine before planting onion, beet, celery or potato. Methyl bromide must be applied under a plastic cover according to the manufacturer's directions.

A permit is required to apply methyl bromide.

Deer, Groundhog and Rabbit

Deer, groundhogs and rabbits can be a serious problem in vegetable plantings, particularly in areas where woodlots or other brush surround vegetable fields. Deer and groundhogs will often root for carrots in harvested fields. Trapping groundhogs and moving them to other areas may reduce the problem.

Hinder is registered as both a deer and rabbit repellent. It can be applied using normal field spraying equipment. The rate to use depends on the severity of the problem. Hinder, at 2–4 L/100 L should be applied at a volume of 450–950 L of water/ha (180–380 L/ac). This results in an actual application range of 9–39 L of Hinder product/ha (3.6–15.6 L/ac).

Hinder acts as a scent repellent. It is important that the edges of the affected fields, particularly areas where the deer or rabbits enter, be thoroughly covered with spray solution. For more information on deer control, see OMAFRA Publication 10, *Deer Control Practices in Agriculture.*

3. Soil Management and Fertilizer Use

For a complete guide to soil fertility, consult OMAFRA Publication 611, *Soil Fertility Handbook.*

Soil Testing

Ontario currently uses about 690,000 tonnes of fertilizer annually. High yields can be produced efficiently only when fertilizer use is related to the fertility level of the soil and to other additions of nutrients in manure, crop residues and other organic sources. At one extreme, on very low-fertility soils, it is occasionally profitable to add as much or more nitrogen, phosphorus or potassium in the fertilizer as a crop removes. At the other extreme, on high fertility soils or following heavy application of manures, fertilizer may not be profitable and occasionally may reduce yields.

Why Soil Test?

The OMAFRA-accredited soil test is the most accurate tool available to Ontario farmers to determine the amounts of phosphorus, potassium and magnesium fertilizers and lime that should be applied for crop production.

Other Methods of Assessing Nutrient Needs

1. Plant analysis of vegetables is a tool that can provide additional information supporting the soil test.

2. Symptoms on leaves are helpful in evaluating some nutrient deficiencies. However, by the time symptoms of potassium and phosphorus deficiencies are visible, yield losses may have already occurred.

3. It is occasionally suggested that a grower apply the amounts of nutrients removed by the crop. This has some application for nitrogen (for some crops, the suggested rate approximates what the plant removes) but has little relevance for other nutrients in Ontario. Some Ontario clay and clay loam soils have sufficient potassium to last many years. Applying potassium each year on those soils is a waste of money and ignores one of the few advantages that clay soils have over coarser-textured soils.

TABLE 3–1.
OMAFRA-Accredited Soil Tests

Refer to Appendix B, *Accredited Soil Testing Laboratories in Ontario*, on page 233, for a list of accredited labs in Ontario.

Materials	What is Analyzed[1]
Soils for Field Crops, Commercial Turf, etc.	• plant-available phosphorus, potassium, magnesium and zinc • pH • lime requirement
Greenhouse Media	• plant-available nitrogen, phosphorus, potassium, calcium, magnesium • pH • total salts
Nutrient Solutions, Water	• plant-available nitrogen, phosphorus, potassium, calcium, magnesium • pH • total salts • sulphates • chlorides

[1] Soil organic matter tests can be useful for herbicide recommendations but are not accredited tests.

Use the OMAFRA-accredited soil testing program along with plant analysis and evidence from nutrient deficiency symptoms as the main guide for determining fertilizer requirements for a specific crop on a specific field. See Table 3–1, *OMAFRA-Accredited Soil Tests*, above.

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The OMAFRA-accredited soil testing program provides recommendations for nitrogen, phosphate, potash and magnesium fertilizer, as well as recommendations for the amount and type of lime to be applied. (See Table 3–1 above.)

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The OMAFRA-recommended fertilizer rates are provided in this publication. They are designed to produce the highest economic yields when accompanied by good or above-average management.

Research shows that higher rates will occasionally produce higher yields but that these increases in yield are likely to be small and not profitable. Some fertilizer is recommended at soil test levels slightly above those where crop response is profitable. This is done to maintain high soil nutrient levels and to allow for some error in sampling the field.

For high-value crops such as tobacco, maximum profit requires essentially the same amount of fertilizer as maximum crop value (maximum yield with high quality). For low-value crops, there may on occasion be a slight yield response to rates of fertilizer above those recommended for maximum profit.

However, trials on farm fields with corn have shown no yield response to rates of fertilizer above those recommended by soil test.

Soil Sampling

Soils may be sampled with a sampling tube or with a shovel. Each field or uniform section of a field should be sampled separately. Take at least 20 soil cores 15 cm deep from fields or areas up to 5 ha in size. Take proportionately more cores for fields larger than 5 ha. The more cores taken, the more likely the soil sample is to provide a reliable measure of the fertility in the field. One sample should not represent more than 10 ha.

Traverse the area sampled in a zigzag pattern to provide a uniform distribution of sampling sites. Sample any parts of a field that differ in appearance of soil or crop, in previous fertilization, manuring or liming separately, even if they are too small to fertilize separately. Avoid sampling recent fertilizer bands, dead furrows, areas adjacent to gravel roads or areas where lime, manure, compost or crop residues have been piled.

Collect the soil in a clean pail. Break the lumps, mix the soil well and forward a soil sample box for testing.

When to Sample

Sample each field once every 2 or 3 years. Potash levels can change quickly where large amounts of nutrients are removed from sandy soils (for example, with crops such as alfalfa hay, corn silage, potatoes or tomatoes) and are not returned. Under these conditions, take samples each year.

To allow time for mailing and analysis, take soil samples in the fall from fields to be fertilized for spring seeding crops. Because of the rush of harvest and the frequency of poor weather late in the fall, it may be more convenient for some growers to sample in the summer.

Soil Tests from Other Laboratories

Each year, a number of farmers ask OMAFRA staff to interpret results from laboratories that are not accredited. Provided the other laboratory uses the identical test used by the OMAFRA-accredited service and expresses their test results in the same units, the OMAFRA fertilizer requirements for phosphate and potash can be determined.

Only OMAFRA-accredited soil tests can be relied on to provide accurate fertilizer recommendations. Be certain that the service you are using is accredited. To be accredited, a laboratory must use OMAFRA-approved testing procedures, must demonstrate acceptable analytical precision and accuracy and must provide the OMAFRA fertilizer recommendations.

A number of laboratories provide soil tests such as exchange capacity, aluminum and copper. These are not accredited by OMAFRA because they have not been found to contribute to better fertilizer recommendations. Research has shown that on Ontario soils, use of exchange capacity to adjust potash recommendations can lead to less reliable recommendations than are now provided.

Sample Boxes and Information Sheets

Soil sample boxes can be obtained from individual laboratories.

A soil test recommendation is affected by manure application, plowing down of legume sod and which crop is to be fertilized. This information is essential for a reliable fertilizer recommendation and should be recorded on the field information sheet that must accompany the soil sample sent in for analysis.

Plant Analysis

Plant analysis measures the nutrient content of plant tissue. Comparing the results against the normal and critical values for the crop can indicate whether nutrient supply is adequate for optimum growth.

Plant analysis is the basis of fertilizer recommendations for tree fruits and grapes, and is a useful supplement to soil testing for evaluation of the fertility status of other crops. It is quite independent of soil testing and can provide a valuable second opinion, especially for phosphorus, potassium, magnesium and manganese, although it has not

been very reliable for nitrogen and zinc. There is no reliable soil test for boron and copper, so plant analysis and visual symptoms are used for diagnosing deficiencies.

Plant analysis has limitations. Expert help in interpreting the results is often needed, since plant analysis does not usually indicate the cause of a deficiency or the amount of fertilizer required to correct it.

Sampling

Time of sampling has a major effect on the results of plant analysis since nutrient levels within a plant vary considerably with the age of the plant. Results are difficult to interpret if samples are taken at times other than those recommended. Nevertheless, plants suspected of being nutrient deficient should be sampled as soon as a problem appears. Samples are best taken from a problem area rather than from the entire field.

Samples for plant analysis should be taken from at least 20 plants distributed throughout the area chosen for sampling. Each sample should consist of at least 100 grams of fresh material. Problem areas should be sampled separately. When taking samples for plant analysis, take care not to contaminate the sample with soil. Even a small amount of soil will cause the results to be invalid, especially for micronutrients.

Sample Preparation

Samples of fresh plant material should be delivered directly to the laboratory. If they are not delivered immediately, they should be dried to prevent spoilage. Samples may be dried in an oven at 65°C or less or dried in the sun, provided precautions are taken to prevent contamination with dust or soil. Avoid contact of samples with galvanized (zinc-coated) metal, brass or copper.

Plant analyses may be obtained from several laboratories in Ontario.

Micronutrient Tests

OMAFRA-accredited tests are available for manganese and zinc. To test for zinc deficiency on corn, the soil test is best used in conjunction with visual symptoms. With manganese, plant analysis, visual symptoms and the soil test are all useful. OMAFRA-accredited tests are not available for boron, copper, iron or molybdenum. Plant analysis is generally a better indicator of deficiencies of these nutrients.

Contamination

Great care is required to prevent contamination of soil samples with micronutrients, particularly zinc. Do not use galvanized (zinc-plated) soil sampling tubes to take soil samples for micronutrient tests. Do not use metal containers to collect and mix samples. Clean, plastic containers in good condition should be satisfactory. Soil samples that have contacted galvanized surfaces are unsatisfactory for zinc soil tests. Be careful to keep dust out of the samples.

Soil Sampling

Micronutrient deficiencies frequently occur in small patches in fields. In these cases, soil or plant analysis taken from the entire field is unlikely to find the problem. Sample problem areas separately.

Fertilizer Recommendations

Changes in Crop or Management

Fertilizer requirements on the OMAFRA soil test report are for specific crops and management. Adjustments in fertilizer requirements may be needed if changes are made in manure applications or if legumes are incorporated. For fertilizer adjustments, refer to Table 3–10, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 28, and Table 3–11, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 29. Changing the crop from the original soil test recommendation will require a new fertilizer recommendation. This can be obtained by looking up the appropriate table under the specific crop section in Chapter 5, *Crop Management Recommendations* on page 49 of this publication.

Soil Acidity and Liming

The pH scale ranging from 0 to 14 is used to indicate acidity and alkalinity. A pH value of 7.0 is neutral; values below 7.0 are acid, and those above 7.0 are alkaline. Most vegetable crops grow well in a soil pH range from 6.0 to 7.5 on mineral soils and from 5.0 to 6.0 on muck soils. To correct soil acidity, ground limestone should be broadcast and worked into the soil at rates determined by soil test. Table 3–2, *Soil pH at Which Lime Is Recommended for Ontario Field Crops*, on page 22, shows the pH values below which lime is recommended and the target soil pH to which soils should be limed for different crops. In

Research shows that higher rates will occasionally produce higher yields but that these increases in yield are likely to be small and not profitable. Some fertilizer is recommended at soil test levels slightly above those where crop response is profitable. This is done to maintain high soil nutrient levels and to allow for some error in sampling the field.

For high-value crops such as tobacco, maximum profit requires essentially the same amount of fertilizer as maximum crop value (maximum yield with high quality). For low-value crops, there may on occasion be a slight yield response to rates of fertilizer above those recommended for maximum profit.

However, trials on farm fields with corn have shown no yield response to rates of fertilizer above those recommended by soil test.

Soil Sampling

Soils may be sampled with a sampling tube or with a shovel. Each field or uniform section of a field should be sampled separately. Take at least 20 soil cores 15 cm deep from fields or areas up to 5 ha in size. Take proportionately more cores for fields larger than 5 ha. The more cores taken, the more likely the soil sample is to provide a reliable measure of the fertility in the field. One sample should not represent more than 10 ha.

Traverse the area sampled in a zigzag pattern to provide a uniform distribution of sampling sites. Sample any parts of a field that differ in appearance of soil or crop, in previous fertilization, manuring or liming separately, even if they are too small to fertilize separately. Avoid sampling recent fertilizer bands, dead furrows, areas adjacent to gravel roads or areas where lime, manure, compost or crop residues have been piled.

Collect the soil in a clean pail. Break the lumps, mix the soil well and forward a soil sample box for testing.

When to Sample

Sample each field once every 2 or 3 years. Potash levels can change quickly where large amounts of nutrients are removed from sandy soils (for example, with crops such as alfalfa hay, corn silage, potatoes or tomatoes) and are not returned. Under these conditions, take samples each year.

To allow time for mailing and analysis, take soil samples in the fall from fields to be fertilized for spring seeding crops. Because of the rush of harvest and the frequency of poor weather late in the fall, it may be more convenient for some growers to sample in the summer.

Soil Tests from Other Laboratories

Each year, a number of farmers ask OMAFRA staff to interpret results from laboratories that are not accredited. Provided the other laboratory uses the identical test used by the OMAFRA-accredited service and expresses their test results in the same units, the OMAFRA fertilizer requirements for phosphate and potash can be determined.

Only OMAFRA-accredited soil tests can be relied on to provide accurate fertilizer recommendations. Be certain that the service you are using is accredited. To be accredited, a laboratory must use OMAFRA-approved testing procedures, must demonstrate acceptable analytical precision and accuracy and must provide the OMAFRA fertilizer recommendations.

A number of laboratories provide soil tests such as exchange capacity, aluminum and copper. These are not accredited by OMAFRA because they have not been found to contribute to better fertilizer recommendations. Research has shown that on Ontario soils, use of exchange capacity to adjust potash recommendations can lead to less reliable recommendations than are now provided.

Sample Boxes and Information Sheets

Soil sample boxes can be obtained from individual laboratories.

A soil test recommendation is affected by manure application, plowing down of legume sod and which crop is to be fertilized. This information is essential for a reliable fertilizer recommendation and should be recorded on the field information sheet that must accompany the soil sample sent in for analysis.

Plant Analysis

Plant analysis measures the nutrient content of plant tissue. Comparing the results against the normal and critical values for the crop can indicate whether nutrient supply is adequate for optimum growth.

Plant analysis is the basis of fertilizer recommendations for tree fruits and grapes, and is a useful supplement to soil testing for evaluation of the fertility status of other crops. It is quite independent of soil testing and can provide a valuable second opinion, especially for phosphorus, potassium, magnesium and manganese, although it has not

been very reliable for nitrogen and zinc. There is no reliable soil test for boron and copper, so plant analysis and visual symptoms are used for diagnosing deficiencies.

Plant analysis has limitations. Expert help in interpreting the results is often needed, since plant analysis does not usually indicate the cause of a deficiency or the amount of fertilizer required to correct it.

Sampling

Time of sampling has a major effect on the results of plant analysis since nutrient levels within a plant vary considerably with the age of the plant. Results are difficult to interpret if samples are taken at times other than those recommended. Nevertheless, plants suspected of being nutrient deficient should be sampled as soon as a problem appears. Samples are best taken from a problem area rather than from the entire field.

Samples for plant analysis should be taken from at least 20 plants distributed throughout the area chosen for sampling. Each sample should consist of at least 100 grams of fresh material. Problem areas should be sampled separately. When taking samples for plant analysis, take care not to contaminate the sample with soil. Even a small amount of soil will cause the results to be invalid, especially for micronutrients.

Sample Preparation

Samples of fresh plant material should be delivered directly to the laboratory. If they are not delivered immediately, they should be dried to prevent spoilage. Samples may be dried in an oven at 65°C or less or dried in the sun, provided precautions are taken to prevent contamination with dust or soil. Avoid contact of samples with galvanized (zinc-coated) metal, brass or copper.

Plant analyses may be obtained from several laboratories in Ontario.

Micronutrient Tests

OMAFRA-accredited tests are available for manganese and zinc. To test for zinc deficiency on corn, the soil test is best used in conjunction with visual symptoms. With manganese, plant analysis, visual symptoms and the soil test are all useful. OMAFRA-accredited tests are not available for boron, copper, iron or molybdenum. Plant analysis is generally a better indicator of deficiencies of these nutrients.

Contamination

Great care is required to prevent contamination of soil samples with micronutrients, particularly zinc. Do not use galvanized (zinc-plated) soil sampling tubes to take soil samples for micronutrient tests. Do not use metal containers to collect and mix samples. Clean, plastic containers in good condition should be satisfactory. Soil samples that have contacted galvanized surfaces are unsatisfactory for zinc soil tests. Be careful to keep dust out of the samples.

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Micronutrient deficiencies frequently occur in small patches in fields. In these cases, soil or plant analysis taken from the entire field is unlikely to find the problem. Sample problem areas separately.

Fertilizer Recommendations

Changes in Crop or Management

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TABLE 3–2.
Soil pH at Which Lime Is Recommended for Ontario Field Crops

Crop	Soil pH Below Which Lime Is Recommended	Target Soil pH[1]
Coarse- and Medium-Textured Mineral Soils (sands, sandy loams, loams and silt loams)		
Perennial legumes, oats, barley, wheat triticale, beans, peas, canola, flax, tomatoes, raspberries, strawberries, all other crops not listed below	6.1	6.5
Corn, soybeans, winter rye, grass hay and pasture, turf, tobacco	5.6	6.0
Potatoes	5.1	5.5
Fine Textured Mineral Soils (clay and clay loams)		
Alfalfa, cole crops, rutabaga	6.1	6.5
Other perennial legumes, oats, barley, wheat, soybeans, beans, peas, canola, flax, tomatoes, all crops not listed below or above	5.6	6.0
Corn, rye, grass hay, pasture	5.1	5.5
Organic Soils (peats and mucks)		
All field and vegetable crops	5.1	5.5

[1] Where a crop is grown in rotation with other crops requiring a high pH (for example, corn in rotation with wheat or alfalfa), it is recommended that the soil be limed to the higher pH.

Ontario, most crops grow quite well at pH values higher than the target pH for which lime is recommended.

The Buffer pH

Different soils with any one soil pH value, say 5.2, will require different amounts of lime to bring the pH to a particular desired level, say 6.0, depending chiefly on the clay and organic matter content of each soil. The soil pH is used to determine which soils need to be limed but a separate soil test, the buffer pH, is run on soils needing lime to determine the amount of lime required. For soils needing lime (based on soil pH), Table 3–3, *Lime Requirements to Correct Soil Acidity Based on Soil pH and Soil Buffer pH*, above, may be used to determine the amount of lime required to reach different "target" soil pH values required for different crops.

Limestone Quality

Calcitic limestone consists largely of calcium carbonate; dolomitic limestone is a mixture of both calcium and magnesium carbonates. Dolomitic limestone should be used on soils with a magnesium soil test of 100 or less, as it is an excellent and inexpensive source of magnesium for

TABLE 3–3.
Lime Requirements to Correct Soil Acidity Based on Soil pH and Soil Buffer pH

Ground limestone required — tonne/ha (based on Agricultural Index of 75)

Buffer pH	Target soil pH = 7.0[1]	Target soil pH = 6.5[2]	Target soil pH = 6.0[3]	Target soil pH = 5.5[4]
7.0	2	2	1	1
6.9	3	2	1	1
6.8	3	2	1	1
6.7	4	2	2	1
6.6	5	3	2	1
6.5	6	3	2	1
6.4	7	4	3	2
6.3	8	5	3	2
6.2	10	6	4	2
6.1	11	7	5	2
6.0	13	9	6	3
5.9	14	10	7	4
5.8	16	12	8	4
5.7	18	13	9	5
5.6	20	15	11	6
5.5	20	17	12	8
5.4	20	19	14	9
5.3	20	20	15	10
5.2	20	20	17	11
5.1	20	20	19	13
5.0	20	20	20	15
4.9	20	20	20	16
4.8	20	20	20	18
4.7	20	20	20	20
4.6	20	20	20	20

[1] Liming to pH 7.0 is recommended only for club-root control on cole crops.
[2] Add lime if soil pH is below 6.1.
[3] Add lime if soil pH is below 5.6.
[4] Add lime if soil pH is below 5.1.

acid soils. On soils with magnesium tests greater than 100, calcitic or dolomitic limestone may be used.

Two main factors affect the value of limestone for soil application. One of these is the amount of acid a given quantity of limestone will neutralize when it is totally dissolved. This is called the "neutralizing value" and is expressed as a percentage of the neutralizing value of pure calcium carbonate. A limestone that will neutralize 90% as much acid as pure calcium carbonate is said to have a neutralizing value of 90. In general, the higher the calcium and magnesium content of a limestone, the higher the neutralizing value.

The second factor that affects the value of limestone as a neutralizer of acidity is the particle size. Limestone rock

TABLE 3–2.
Soil pH at Which Lime is Recommended for Ontario Field Crops

Crop	Soil pH Below Which Lime is Recommended	Target Soil pH[1]
Coarse- and Medium-Textured Mineral Soils (sands, sandy loams, loams and silt loams)		
Perennial legumes, oats, barley, wheat triticale, beans, peas, canola, flax, tomatoes, raspberries, strawberries, all other crops not listed below	6.1	6.5
Corn, soybeans, winter rye, grass hay and pasture, turf, tobacco	5.6	6.0
Potatoes	5.1	5.5
Fine Textured Mineral Soils (clay and clay loams)		
Alfalfa, cole crops, rutabaga	6.1	6.5
Other perennial legumes, oats, barley, wheat, soybeans, beans, peas, canola, flax, tomatoes, all crops not listed below or above	5.6	6.0
Corn, rye, grass hay, pasture	5.1	5.5
Organic Soils (peats and mucks)		
All field and vegetable crops	5.1	5.5

[1] Where a crop is grown in rotation with other crops requiring a high pH (for example, corn in rotation with wheat or alfalfa), it is recommended that the soil be limed to the higher pH.

Ontario, most crops grow quite well at pH values higher than the target pH for which lime is recommended.

The Buffer pH

Different soils with any one soil pH value, say 5.2, will require different amounts of lime to bring the pH to a particular desired level, say 6.0, depending chiefly on the clay and organic matter content of each soil. The soil pH is used to determine which soils need to be limed but a separate soil test, the buffer pH, is run on soils needing lime to determine the amount of lime required. For soils needing lime (based on soil pH), Table 3–3, *Lime Requirements to Correct Soil Acidity Based on Soil pH and Soil Buffer pH*, above, may be used to determine the amount of lime required to reach different "target" soil pH values required for different crops.

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7.0	2	2	1	1
6.9	3	2	1	1
6.8	3	2	1	1
6.7	4	2	2	1
6.6	5	3	2	1
6.5	6	3	2	1
6.4	7	4	3	2
6.3	8	5	3	2
6.2	10	6	4	2
6.1	11	7	5	2
6.0	13	9	6	3
5.9	14	10	7	4
5.8	16	12	8	4
5.7	18	13	9	5
5.6	20	15	11	6
5.5	20	17	12	8
5.4	20	19	14	9
5.3	20	20	15	10
5.2	20	20	17	11
5.1	20	20	19	13
5.0	20	20	20	15
4.9	20	20	20	16
4.8	20	20	20	18
4.7	20	20	20	20
4.6	20	20	20	20

[1] Liming to pH 7.0 is recommended only for club-root control on cole crops.
[2] Add lime if soil pH is below 6.1.
[3] Add lime if soil pH is below 5.6.
[4] Add lime if soil pH is below 5.1.

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Two main factors affect the value of limestone for soil application. One of these is the amount of acid a given quantity of limestone will neutralize when it is totally dissolved. This is called the "neutralizing value" and is expressed as a percentage of the neutralizing value of pure calcium carbonate. A limestone that will neutralize 90% as much acid as pure calcium carbonate is said to have a neutralizing value of 90. In general, the higher the calcium and magnesium content of a limestone, the higher the neutralizing value.

The second factor that affects the value of limestone as a neutralizer of acidity is the particle size. Limestone rock

TABLE 3–4.
Example Calculation of the Fineness Rating of Limestone

Particle Size	% of sample		Effectiveness Factor	
Coarser than No. 10 sieve[1]	10	X	0.0	= 0
No. 10 sieve to No. 60 sieve	40	X	0.4	= 16
Passing through No. 60 sieve	50	X	1.0	= 50
			Fineness Rating	= 66

[1] A No. 10 sieve has wires spaced 2.0 mm and a No. 60 sieve has wires spaced 0.25 mm apart.

has much less surface area to react with acid soil than finely powdered limestone and, hence, it neutralizes acidity much more slowly — so slowly that it is of little value. The calculation of a fineness rating for ground limestone is illustrated in Table 3–4, *Example Calculation of the Fineness Rating of Limestone*, above.

The Agricultural Index

Some means of combining the neutralizing value and the fineness rating is needed to compare various limestones that are available. The index that has been developed in Ontario to do this is called the Agricultural Index.

$$\text{The Agricultural Index} = \frac{\text{neutralizing value} \times \text{fineness rating}}{100}$$

The Agricultural Index can be used to compare the relative value of different limestones for neutralization of soil acidity. Lime with a high Agricultural Index is worth proportionately more than lime with a low Index because it may be applied at a lower rate. If two ground limestones, A and B, have Agricultural Indices of 50 and 80 respectively, the rate of application of limestone A required for a particular soil will be 80/50 x the rate required for limestone B. Limestone A spread on your farm is worth 50/80 x the price of limestone B per tonne.

Recommendations from the OMAFRA soil test service are based on limestone with an Agricultural Index of 75. If the Agricultural Index is known, then the rate of application specifically for limestone of that quality can be calculated. This can be done using the following equation:

$$\text{Limestone application rate from soil test} \times \frac{75}{\text{Agricultural Index of your limestone}} = \text{rate of application of your limestone}$$

For example, if you have a limestone requirement by soil test of 9 t/ha, and your most suitable source of limestone from a quality and price standpoint has an Agricultural Index of 90, you should apply 75/90 x 9 = 7.5 t/ha.

The Agricultural Index does not provide information about magnesium content. Dolomitic limestone should be used on soils low in magnesium.

Tillage Depth

Lime recommendations presented here should raise the pH of the top 15 cm of a soil to the listed target pH. If the soil is plowed to a lesser or greater depth than 15 cm, proportionately more or less lime is required to reach the same target pH. Where reduced tillage depths are used, rates of application should be reduced proportionately. More frequent liming will be needed.

Lowering Soil pH

On soils with pH values below 6.5, it is possible to lower the pH (make the soil more acid) by adding sulphur or ammonium sulphate. This may be desirable for some crops, for example, potatoes, for scab control but usually will not be suitable for rotation crops. pH cannot be made to flip flop from a low pH to a more moderate pH year to year. If the soil pH is above 6.5, it is not advisable and also usually quite impractical to lower the soil pH because of the very large amounts of sulphur or ammonium sulphate required.

Nitrogen

Nitrogen fertilizer recommendations for vegetable crops are based on estimated crop requirements. Recommended rates are presented under the heading *Fertilizers* in the section on individual crops in Chapter 5, *Crop Management Recommendations*, starting on page 49. Rates are adjusted downward if manure is applied or if the previous crop contains perennial legumes such as alfalfa.

To protect crop quality and avoid surface and groundwater pollution, the combined application of fertilizer, manure, sewage sludge and other sources of nitrogen should not supply plant-available nitrogen in excess of the crop's requirement.

Phosphate and Potash

Phosphate and potash recommendations in this publication are based on Ontario Ministry of Agriculture, Food and Rural Affairs soil tests (see Table 3–5, *Phosphorus Requirements – Vegetables on Mineral Soils*, on page 24 and Table 3–6, *Potassium Requirements — Vegetables on Mineral Soils*, and Table 3–7, *Phosphorus and Potassium*

TABLE 3–5.
Phosphorus Requirements – Vegetables on Mineral Soils

Phosphorus Soil Test (ppm P in soil)	Rating	Phosphate (P_2O_5) Required – kg/ha							
		Beans (lima) Beans (snap) Peas	Radish	Sweet Corn Asparagus (established)	Beet Carrot Lettuce Onion Parsnip Rutabaga Spinach Horseradish	Potato	Cucumber Muskmelon Pumpkin Squash Tomato[1] Watermelon	Celery Rhubarb	Broccoli[2] Brussels sprouts[2] Cabbage[2] Cauliflower[2] Eggplant[1] Pepper[1] Asparagus (nursey and new plantings)
0–3	Low	80	80	110	180	200	230	230	270
4–5		60	70	100	170	200	230	230	260
6–7		50	60	90	170	190	220	220	250
8–9		40	60	70	160	190	220	220	240
10–12	Medium	30	50	50	160	180	210	220	230
13–15		20	50	20	150	170	190	210	220
16–20	High	0	40	20	140	160	170	190	200
21–25		0	40	20	120	140	140	160	170
26–30		0	30	20	100	120	110	140	140
31–40	Very High	0	30	0	80	90	80	110	110
41–50		0	20	0	50	50	50	80	80
51–60		0	0	0	30	30	30	50	50
61–80	Excessive	0	0	0	0	30	0	0	0
80+		0	0	0	0	30	0	0	0

[1] For transplanted tomatoes, pepper and eggplants, apply a starter solution, such as 1 L of 10-34-0 per 100 L of water, or 1 L of 6-24-6 per 75 L at planting.
[2] For transplanted broccoli, Brussels sprouts, cabbage and cauliflower, if no insecticide is used in the planting water, apply a starter solution high in nitrogen such as 20-20-20 at 1 kg/200 L. Under high temperatures and in dry, sandy soils, use half the concentration of fertilizer.

Requirements — Vegetables on Muck Soils, on page 25. These tables should be used only with OMAFRA-accredited soil tests. Non-accredited tests may use extractants that pull out different amounts of nutrients, so they will not give correct answers if used with the OMAFRA tables.

Where a soil test is not available, a rough estimate of requirements can be obtained from these tables using the following guidelines:

- If the field has been fertilized regularly for a number of years or heavily in recent years, use one of the rates of phosphate and potash recommended for the MEDIUM soil test rating.
- If the field has received little fertilizer in the past, use one of the rates recommended for a LOW soil test rating.

Soils testing excessive (E) for phosphorus contain much more plant-available phosphorus than required for most crops. Phosphorus fertilizers, compost, manure, sewage sludge or other sources of phosphorus should not be applied to these soils because of the increased risk of water pollution.

The rating system used for soil test phosphorous is intended to be used to evaluate the likelihood of a crop response to applied phosphorous. The risk of surface water contamination by phosphorous may be increased at higher soil test phosphorous levels. However, since phosphorous binds tightly to soil particles, the movement of soil off the field through erosion is also a major factor in determining the risk of surface water contamination. It is for this reason that the risk of surface water contamination by phosphorous cannot be based on a soil test alone. Wherever soil tests are very high or excessive, applications of any source of phosphorous should be guided by a "phosphorous index" (see the OMAFRA Factsheet, *Determining the Phosphorous Index for a Field,* Order No. 98-079). A phosphorous index can rank the relative risk of surface water contamination for applications made to a particular area of land. It will also determine the maximum application rates if manure is applied and the required setbacks from watercourses.

TABLE 3–6.
Potassium Requirements — Vegetables on Mineral Soils

Potassium Soil Test (ppm K in soil)	Rating	Potash (K_2O) Required – kg/ha								
		Radish	Beans (lima) Beans (snap) Peas	Sweet Corn	Tomato (paste & fresh market) Cucumber Muskmelon Pumpkin Squash Watermelon	Beet Carrot Lettuce Onion Parsnip Potato Spinach Horseradish	Broccoli Brussels sprouts Cabbage Cauliflower Eggplant Pepper	Celery Rhubarb Rutabaga[1]	Asparagus	Tomatoes[1] (whole pack)
0–15	Low	60	120	170	230	230	270	340	420	660
16–30		60	110	160	220	220	250	330	400	640
31–45		50	90	140	200	210	230	310	360	600
46–60		50	80	110	180	190	200	280	320	560
61–80		40	60	80	140	160	170	250	280	480
81–100		30	40	50	100	130	130	200	250	400
101–120	Medium	30	30	30	70	100	100	150	220	340
121–150		20	0	0	50	80	80	90	190	300
151–180		20	0	0	40	50	50	50	160	280
181–210	High	0	0	0	0	0	0	0	130	140
211–250	Very High	0	0	0	0	0	0	0	80	70
250+	Excessive	0	0	0	0	0	0	0	0	0

[1] For rutabagas and tomatoes on soils with magnesium tests less than 100, the required amount of potash is adjusted downward from the amounts shown in this table to a minimum of 50% at 50 ppm Mg.

TABLE 3–7.
Phosphorus and Potassium Requirements — Vegetables on Muck Soils

Phosphorus					Potassium				
		Phosphate required kg P_2O_5/ha					Potash required kg K_2O/ha		
Phosphorus Soil Test – ppm P in soil	Rating	Beet Broccoli Brussels sprouts Cabbage Carrot Cauliflower	Lettuce Onion[1] Parsnip Potato Radish Spinach	Celery	Potassium Soil Test – ppm K in soil	Rating	Broccoli Brussels sprouts Cabbage Cauliflower	Carrot Celery Onion Parsnip Potato	Beet Lettuce Radish Spinach
0–3	Low	100		120	0–15	Low	200	230	100
4–5		100		120	16–30		190	220	100
6–7		100		120	31–45		170	210	90
8–9		100		120	46–60		150	200	80
10–12		90		120	61–80		120	170	60
13–15		90		110	81–100		90	150	40
16–20	Medium	80		100	101–120	Medium	70	120	30
21–25		70		90	121–150		50	80	20
26–30		60		80	121–180		40	40	20
31–40	High	50		70	181–210	High	0	0	0
41–50		30		50	211–250	Very High	0	0	0
51–60	Very High	20		40	250+	Excessive	0	0	0
61–80	Excessive	0		0					
80+		0		0					

[1] If maturity of onions is a problem on organic soils less than 40 cm deep, additional phosphate may be required.

TABLE 3–5.
Phosphorus Requirements – Vegetables on Mineral Soils

Phosphorus Soil Test (ppm P in soil)	Rating	Phosphate (P_2O_5) Required – kg/ha							
		Beans (lima) Beans (snap) Peas	Radish	Sweet Corn Asparagus (established)	Beet Carrot Lettuce Onion Parsnip Rutabaga Spinach Horseradish	Potato	Cucumber Muskmelon Pumpkin Squash Tomato[1] Watermelon	Celery Rhubarb	Broccoli[2] Brussels sprouts[2] Cabbage[2] Cauliflower[2] Eggplant[1] Pepper[1] Asparagus (nursey and new plantings)
0–3	Low	80	80	110	180	200	230	230	270
4–5		60	70	100	170	200	230	230	260
6–7		50	60	90	170	190	220	220	250
8–9		40	60	70	160	190	220	220	240
10–12	Medium	30	50	50	160	180	210	220	230
13–15		20	50	20	150	170	190	210	220
16–20	High	0	40	20	140	160	170	190	200
21–25		0	40	20	120	140	140	160	170
26–30		0	30	20	100	120	110	140	140
31–40	Very High	0	30	0	80	90	80	110	110
41–50		0	20	0	50	50	50	80	80
51–60		0	0	0	30	30	30	50	50
61–80	Excessive	0	0	0	0	30	0	0	0
80+		0	0	0	0	30	0	0	0

[1] For transplanted tomatoes, pepper and eggplants, apply a starter solution, such as 1 L of 10-34-0 per 100 L of water, or 1 L of 6-24-6 per 75 L at planting.
[2] For transplanted broccoli, Brussels sprouts, cabbage and cauliflower, if no insecticide is used in the planting water, apply a starter solution high in nitrogen such as 20-20-20 at 1 kg/200 L. Under high temperatures and in dry, sandy soils, use half the concentration of fertilizer.

Requirements — Vegetables on Muck Soils, on page 25. These tables should be used only with OMAFRA-accredited soil tests. Non-accredited tests may use extractants that pull out different amounts of nutrients, so they will not give correct answers if used with the OMAFRA tables.

Where a soil test is not available, a rough estimate of requirements can be obtained from these tables using the following guidelines:

- If the field has been fertilized regularly for a number of years or heavily in recent years, use one of the rates of phosphate and potash recommended for the MEDIUM soil test rating.
- If the field has received little fertilizer in the past, use one of the rates recommended for a LOW soil test rating.

Soils testing excessive (E) for phosphorus contain much more plant-available phosphorus than required for most crops. Phosphorus fertilizers, compost, manure, sewage sludge or other sources of phosphorus should not be applied to these soils because of the increased risk of water pollution.

The rating system used for soil test phosphorous is intended to be used to evaluate the likelihood of a crop response to applied phosphorous. The risk of surface water contamination by phosphorous may be increased at higher soil test phosphorous levels. However, since phosphorous binds tightly to soil particles, the movement of soil off the field through erosion is also a major factor in determining the risk of surface water contamination. It is for this reason that the risk of surface water contamination by phosphorous cannot be based on a soil test alone. Wherever soil tests are very high or excessive, applications of any source of phosphorous should be guided by a "phosphorous index" (see the OMAFRA Factsheet, *Determining the Phosphorous Index for a Field,* Order No. 98-079). A phosphorous index can rank the relative risk of surface water contamination for applications made to a particular area of land. It will also determine the maximum application rates if manure is applied and the required setbacks from watercourses.

TABLE 3–6.
Potassium Requirements — Vegetables on Mineral Soils

Potassium Soil Test (ppm K in soil)	Rating	Potash (K_2O) Required – kg/ha								
		Radish	Beans (lima) Beans (snap) Peas	Sweet Corn	Tomato (paste & fresh market) Cucumber Muskmelon Pumpkin Squash Watermelon	Beet Carrot Lettuce Onion Parsnip Potato Spinach Horseradish	Broccoli Brussels sprouts Cabbage Cauliflower Eggplant Pepper	Celery Rhubarb Rutabaga[1]	Asparagus	Tomatoes[1] (whole pack)
0–15	Low	60	120	170	230	230	270	340	420	660
16–30		60	110	160	220	220	250	330	400	640
31–45		50	90	140	200	210	230	310	360	600
46–60		50	80	110	180	190	200	280	320	560
61–80		40	60	80	140	160	170	250	280	480
81–100		30	40	50	100	130	130	200	250	400
101–120	Medium	30	30	30	70	100	100	150	220	340
121–150		20	0	0	50	80	80	90	190	300
151–180		20	0	0	40	50	50	50	160	280
181–210	High	0	0	0	0	0	0	0	130	140
211–250	Very High	0	0	0	0	0	0	0	80	70
250+	Excessive	0	0	0	0	0	0	0	0	0

[1] For rutabagas and tomatoes on soils with magnesium tests less than 100, the required amount of potash is adjusted downward from the amounts shown in this table to a minimum of 50% at 50 ppm Mg.

TABLE 3–7.
Phosphorus and Potassium Requirements — Vegetables on Muck Soils

Phosphorus					Potassium				
		Phosphate required kg P_2O_5/ha					Potash required kg K_2O/ha		
Phosphorus Soil Test – ppm P in soil	Rating	Beet Broccoli Brussels sprouts Cabbage Carrot Cauliflower	Lettuce Onion[1] Parsnip Potato Radish Spinach	Celery	Potassium Soil Test – ppm K in soil	Rating	Broccoli Brussels sprouts Cabbage Cauliflower	Carrot Celery Onion Parsnip Potato	Beet Lettuce Radish Spinach
0–3	Low	100		120	0–15	Low	200	230	100
4–5		100		120	16–30		190	220	100
6–7		100		120	31–45		170	210	90
8–9		100		120	46–60		150	200	80
10–12		90		120	61–80		120	170	60
13–15		90		110	81–100		90	150	40
16–20	Medium	80		100	101–120	Medium	70	120	30
21–25		70		90	121–150		50	80	20
26–30		60		80	121–180		40	40	20
31–40	High	50		70	181–210	High	0	0	0
41–50		30		50	211–250	Very High	0	0	0
51–60	Very High	20		40	250+	Excessive	0	0	0
61–80	Excessive	0		0					
80+		0		0					

[1] If maturity of onions is a problem on organic soils less than 40 cm deep, additional phosphate may be required.

TABLE 3–8.
Application Rates for Magnesium, Calcium and Micronutrients

Nutrient	Soil [1]		Source	% Composition	Foliar	
	Nutrient kg/ha	Product kg/ha			Nutrient kg/1,000 L	Product kg/1,000 L
Calcium (Ca)[2]	–	–	calcium chloride	36% Ca	1.9	5.0
	–	–	calcium nitrate	19% Ca	1.9	10.0
Magnesium (Mg)	120–260	2 t/ha	dolomitic limestone	6–13% Mg	–	–
	30	300	epsom salts	10.5% Mg	1.9	18
	30	300	sulphate of potash magnesia	11%	–	–
Boron (B)	1.0–3.0		various materials available	12–21% B	0.1–0.3	–
Copper (Cu)	7.0–14.5	28–60	copper sulfate	25% Cu	0.5–1.5	2–6
	–		copper chelates	5–13% Cu	0.5–1.5	–
Manganese (Mn)[3]	–	–	manganese sulfate	28% Mn	0.5–1.0	1.8–3.6
	–	–	manganese chelates	5–12% Mn	0.5–1.0	–
Molybdenum (Mo)	–	–	sodium molybdate	39% Mo	0.1–0.25	0.25–0.6
Zinc (Zn)	4–14	11–33	zinc sulfate	36% Zn	0.6	1.6
	4–14	–	zinc oxysulfate	18–36% Zn	–	–
	–	–	zinc chelate	9–14% Zn	0.6	–

[1] Double rates for muck soil, except dolomitic limestone.
[2] For blackheart of celery.
[3] For onions use 1.5 to 2.75 kg Mn/1,000 L.

Some clay and clay loam soils are naturally high in potassium and do not require any potash fertilizers. Only a soil test can adequately determine potash requirements.

Magnesium

Magnesium is a plant nutrient that is naturally plentiful in many Ontario soils. Soils with OMAFRA magnesium soil test results below 20 require magnesium application for the production of most crops. Very few Ontario soils have magnesium tests below 20. If the soil pH is below 6.0, the most effective and inexpensive means of supplying magnesium is by the application of dolomitic lime. If the pH is above 6.0, and the soil test 20 or below, magnesium can be supplied by either magnesium sulfate or sulfate of potash magnesia, which is a mixture of sulfate of potash and magnesium sulfate. Apply 30 kg/ha of actual soluble magnesium. These latter sources of magnesium are usually quite expensive compared to supplying magnesium from dolomitic limestone.

Potassium competes with magnesium for uptake by crops, and potash applications can therefore induce or increase magnesium deficiency. For this reason, it is important to monitor soil potassium levels and to carefully control potash fertilizer applications on low magnesium soils.

A magnesium deficiency may occur on carrots, celery, tomatoes and spinach. The usual symptom is yellowing of the older leaves while the veins remain dark green. Potato plants may become lighter in colour.

For magnesium appliction rates, see Table 3–8, *Application Rates for Magnesium, Calcium and Micronutrients*, above. For additional information to correct a deficiency, consult the specific crop section in Chapter 5, starting on page 49.

Calcium

Calcium deficiency has not been a problem on Ontario soils with soil pH adequate for vegetable crop growth. Adequate soil pH is a reliable indicator of adequate calcium in the soil. Occasional calcium deficiencies may show up in some crops (e.g., blossom end rot in tomatoes, blackheart or tipburn in celery, lettuce and cabbage) caused by difficulties in transporting calcium through the plant. Nitrogen management to control vegetative growth and good soil management to ensure adequate root volume will help to prevent calcium shortages in the plant. For calcium application rates, see Table 3–8, above. To manage calcium-related disorders, consult the specific crop section in Chapter 5, starting on page 49.

Micronutrients

Micronutrient elements should not be combined with insecticide, fungicide or herbicide sprays unless the manufacturer's directions indicate that this may be done or experience has shown that they are compatible. Micronutrient elements should be applied only on competent advice or where experience has proven their application to be necessary. Soil or foliar applications can be made. Soil applications are generally made at soil-preparation time, and foliar applications are applied during the growing season. A sticker-spreader may be useful for micronutrient sprays.

For micronutrient application rates, see Table 3–8 on page 26.

Manganese

The general symptoms of manganese deficiency are interveinal chlorosis of leaves, which begins in the younger foliage and may eventually affect the whole plant. A russetting, curling and dwarfing of the foliage occurs in beets. Other crops susceptible to manganese deficiency are beans, lettuce, celery and onions.

Preventing and Correcting Manganese Deficiency

Manganese is less available at high soil pH, so it is important not to add more lime than is needed to correct soil acidity. Spray applications have proven to be more effective than soil applications. Apply sprays when the plants are about one-third grown, or sooner if this deficiency is identified. Two or more sprays may be necessary at 10-day intervals. For materials and rates to correct a deficiency in beans, beets, celery, lettuce and onions, consult the specific crop section in Chapter 5, starting on page 49.

Copper

Copper soil tests are quite unreliable on Ontario soils, but plant analysis is useful. Copper is unlikely to be deficient on mineral soil, except perhaps on very sandy soils. Copper deficiency does occur on organic soils and is best diagnosed by plant analysis. When organic soils are first brought into cultivation, copper should be applied to the soil at 14 kg copper/ha for each of the first 3 years. (See the section *Managing Soil Organic Matter* on page 34.)

Lettuce leaves that are deficient in copper lose their firmness (this is referred to as being "rabbit-eared") and become chlorotic; the plants become bleached on the stems and leaf margins. Onions produce thin, pale yellow scales that cause poor colour and keeping quality. A lack of copper also causes poor colour in carrots.

TABLE 3–9.
Zinc Soil Test Interpretation

Zinc Soil Test[1]	Suggested Treatments
greater than 200	Contamination of the sample or of the field is likely.
25 to 200	Soil zinc availability is adequate for most field-grown crops.
15 to 25	Zinc availability is adequate for most field crops but is bordering on deficiency for corn. If the field sampled is uneven in soil texture, pH, or erosion, some areas may respond to zinc applications. Deficiency symptoms at the 4-to-6 leaf stage are a reliable indication of zinc deficiency (see the OMAFRA Factsheet, *Zinc Requirements for Field Crops*, Order No. 83-089).
less than 15	Zinc is likely to be deficient for corn and should be applied in the fertilizer.

[1] These values are indices of zinc availability based on extractable soil zinc and soil pH.

Extreme care is necessary using foliar sprays with copper sulphate, because injury to foliage may occur readily. Competent advice on the use of copper sprays is necessary. For additional information to correct a copper deficiency, consult the specific crop section in Chapter 5, starting on page 49.

Zinc

Preventing and Correcting Zinc Deficiency

Corn and onions may show zinc deficiency in Ontario. Zinc deficiency has been reported in beans in other areas, but appears to be rare in Ontario. High phosphorus in the soil and/or in the fertilizer can cause or increase the severity of zinc deficiency. Apply only the recommended amount of phosphorus. Use of animal manures can prevent or reduce zinc deficiency.

Zinc deficiency can be prevented by the application of zinc fertilizer to the soil at a rate of 4 kg Zn/ha. Up to 14 kg Zn/ha can be broadcast, which will correct a deficiency for 3 years. Not more than 4 kg/ha should be banded, however. Early in the growing season, foliar sprays can be used to correct a deficiency after the symptoms have appeared. See Table 3–9, *Zinc Soil Test Interpretation*, above. For materials and rates to correct a deficiency, consult the sections *Onion & Leek* on page 91 and *Sweet Corn* on page 129.

Boron

Boron is required on some soils for rutabagas, carrots, celery, beets, spinach and cole crops. Boron deficiencies often occur during dry weather, and the response to boron may be inconsistent. As a result, it has not been

possible to develop a reliable soil test. Visual symptoms and plant analysis are useful to predict boron requirements in plants.

A lack of boron causes a breakdown of the young tissue resulting in slow growth, tissue cracking, blackening and misshapen plants. In addition, the leaves of beets and spinach become twisted with light spots on the petioles. Internal breakdown (internal black spot) may occur in the roots or may appear on the root surface as external cankers. Broccoli and cauliflower show leaf rolling, deformed buds, hollow stems and brown heads. Cabbage develops internal dead spots and hollow stems. Celery petioles show reddish-brown spots called "cat-scratches." Rutabagas develop water-soaked internal areas known as "water-core."

Because boron is needed only in very small quantities and since an overdose is toxic, extreme care should be taken in its use. Continued applications should be made only on expert advice. Application of boron to mineral soils has not been universally successful; foliar sprays have generally given faster and more effective results. Spray when the young plants are about 8 cm high. A second application may be required. On request, boron fertilizers may be mixed with ordinary fertilizers by manufacturers. Boron should not be banded. For materials and rates to correct a boron deficiency in beets, carrots, celery, cole crops, rutabaga and spinach, consult the specific crop section in Chapter 5, starting on page 49.

Molybdenum

Deficiency symptoms on cole crops start with cupping of the leaf margins and interveinal chlorosis of the younger leaves. As the leaves develop, twisting of the midrib and irregular development of the leaf tissue cause a strap- or whiplike appearance known as "whiptail." The early symptoms of molybdenum deficiency in other crops are similar to nitrogen deficiency. Later symptoms are interveinal mottling of leaves with chlorotic areas becoming puffy, marginal cupping and scorching of leaves and twisting and distortion of younger leaves. Molybdenum deficiency may occur on onions when grown on moderately acid-to-strongly acid muck soils.

This deficiency occurs more often on sandy, acid soils; however, it may occur even in neutral soils if soil molybdenum reserves are depleted by heavy cropping. Molybdenum availability to plants increases with an increase in pH and differs from the other trace elements. Consequently, liming acid soil may be a good practice to overcome molybdenum deficiency. Molybdenum can also be applied in the transplanting water at the rate of 30–40 g of sodium molybdate per 100 L of water, each plant receiving 0.3 L of this solution. For materials and rates to correct a molybdenum deficiency in cole crops and onions, consult the specific crop section in Chapter 5, starting on page 49.

TABLE 3–10.
Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down

Type of Sod	For All Crops, Deduct from N Requirement kg N/ha
Less than 1/3 legume	0
1/3 to 1/2 legume	55
1/2 or more legume	100
Perennial legumes seeded and plowed the same year	45[1]
Soybean and field bean residue	0

[1] Applies where the legume stand is thick and over 40 cm high.

Adjustments to Fertilizer Recommendations

Adjustment for Legumes Plowed Down

When sod containing perennial legumes such as alfalfa, trefoil and clover are plowed under, they supply an appreciable amount of nitrogen to the following crop. Table 3–10, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, above, shows reductions that should be made in nitrogen fertilizer applications to crops following sod containing legumes.

Manure

A large number of Ontario farms produce livestock, generating over 33 million tonnes of manure. Proper management of the nutrients from manure is essential for optimum economic benefit to the farmer with minimal impact on the environment.

The Value of Manure

The value of manure in crop production is often underestimated. Manure contains all of the nutrients needed by crops but not necessarily in the proportions needed for specific soil and crop conditions. In addition to nitrogen, phosphorus and potash, manure contains many secondary nutrients and micronutrients, as well as organic matter that helps to build and maintain soil structure. See Table 3–11, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 29.

TABLE 3–11.

Average Amounts of Available Nutrients for Different Types of Manure

Nutrient values based on average analysis results for over 700 samples.
There are large variations between different manures, so a manure analysis is your best guide to nutrient availability.

Manure	Average Dry Matter	Available Nitrogen[1] Spring 1 day	Available Nitrogen[2] Spring not incorp.	Available P_2O_5[3]	Available K_2O[4]
		kg/1,000 L (lb/1,000 gal)			
Liquid dairy	6.5%	1.6 (16)	.6 (6)	.7 (7)	3 (30)
Liquid hog	3.6%	2.6 (26)	.7 (7)	1.1 (11)	2 (20)
Liquid poultry	8.0%	6.1 (61)	1.7 (17)	2.5 (25)	3.4 (34)
Liquid biosolids (sludge)[5]	4.4%	1.2 (12)	.6 (6)	1.3 (13)	0.2 (2)
		kg/tonne (lb/ton)			
Solid biosolids	36%	1.5 (3)	0.75 (1.5)	11 (22)	0 (0)
Solid poultry	49%	11.5 (21)	6 (12)	9 (18)	12.5 (25)
Solid dairy	20%	1.5 (3)	0.7 (1.4)	1.5 (3)	5.5 (11)
Solid beef	27%	1.5 (3)	0.75 (1.5)	1.5 (3)	7 (14)

[1] Nitrogen based on spring application, incorporated within 24 hours.
[2] Nitrogen based on spring application, not incorporated (i.e., on soil surface for over 7 days).
[3] Phosphate from manure or biosolids is assumed to be 40% as available as that in manufactured fertilizer in the year of application.
[4] Potash from manure or biosolids is assumed to be 90% as available as that in manufactured fertilizer in the year of application.
[5] For biosolids (e.g., sewage sludge), you must get a certificate of approval from your local MOE office. This can take up to 6 months.

Manure Analysis

Manure analysis is necessary because the quantities of nutrients contained in manure vary from farm to farm, especially the phosphorus and potash components. The type of livestock, ration, bedding, added liquids and storage system all affect the final nutrient analysis.

A manure analysis is available from several laboratories in Ontario. An analysis should be performed after complete agitation or thorough mixing, each time the storage is emptied (e.g., spring and fall). After several analyses, a trend in results will be evident, and sampling can be limited to major changes in ration or other management factors.

When sending a sample to the lab, fill a 2-L plastic jar half-full, cover, and place in a plastic bag and store in a cool place until shipping. Analysis should include total nitrogen, ammonium-nitrogen (NH_4-N), phosphorus, potassium and dry matter. Ontario labs send back analysis results with percentages for nitrogen, phosphorus, potassium and dry matter as well as mg/kg (or ppm) of ammonium-nitrogen. Percentages for phosphorus and potassium from manure are converted to commercial P_2O_5 and K_2O equivalents and commercial fertilizer reductions are given. Table 3–11, above, summarizes average amounts of nutrients for different types of manure.

Long-Term Value of Manure

The long-term availability of phosphorus (P), potassium (K), magnesium, zinc or manganese from previous manure applications is best estimated by soil testing. Application of large quantities of manure over time can result in high levels of available phosphorus and potassium in soils. Manure also contributes other plant nutrients and organic matter to soil that may be of some long-term value.

Most of the available nitrogen in manure is used by the crop or is lost during the first growing season following application. The remaining organic nitrogen becomes available in small, diminishing quantities in the succeeding years. Generally, the amount of residual nitrogen from one application is too small to make a practical difference in nitrogen recommendations for a crop. However, where manure is applied regularly to the same field, there can be significant residual nitrogen available for a crop. The soil test for phosphorus and potassium should be used to measure residual phosphorus and potassium from manure applications.

Crop Requirements

Soil test results and yield goals will determine the maximum economic application rate and/or additional fertilizer requirements. If manure is applied to meet the entire nitrogen requirements of a corn crop, there will usually be more P and K applied than the crop will

remove, and soil test levels will increase. For liquid manure, an application goal of two-thirds to three-quarters of the nitrogen requirements for a corn crop is a reasonable compromise. The release of nitrogen is much less predictable with solid manure, because of the high carbon content of the bedding material. Due to difficulty in even application for both solid and liquid manure, starter fertilizer is still recommended unless soil test results indicate that no additional nutrients are needed.

Residual nitrogen from legume crops should be taken into account when determining additional nitrogen needs from manure or fertilizer (see Table 3–10, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 28).

Soil compaction is a problem for many farmers. It leads to, among other things, poor drainage and decreased aeration. The best way to reduce or avoid soil compaction is to spread manure when the soil is dry. Loads should be kept below about 5 tons per axle. These points should be considered in the selection of spreading equipment and in the timing of spreading (i.e., summer vs. spring vs. fall application). Spring spreading is often carried out on fields that are too wet, and it is not unusual for strips of stunted crops to serve as an indicator of the wheel track locations.

More detailed information on manure and nutrient values is available in OMAFRA Publication 296, *Field Crop Recommendations.*

Biosolids

Biosolids from off the farm, such as sludge from municipal sewage treatment plants, can be a useful source of nutrients and organic matter. Guidelines are available from OMAFRA and the Ministry of the Environment (MOE). A Certificate of Approval for land application is required and is available from MOE. An analysis of nutrients applied should be given by the applicator to the landowner whenever biosolids are applied.

Environmental Concerns With Manure

Using manure to meet but not exceed crop nutrient needs will help minimize nutrient losses to the environment. However, care should be taken to avoid manure contamination into streams from erosion, surface and tile runoff.

Spreading manure in the winter and early spring is not recommended because of the potential for runoff to surface water. The fate of the first meltwater following manure application determines whether this will be a problem or not. This practice should not be incorporated into a nutrient management plan. In years when winter spreading may be necessary, care must be taken to select fields where there is no risk of runoff to surface water.

Rain can cause organic nitrogen to wash into streams if manure has been applied to unprotected cropland. Phosphorus, attached to soil particles, can be carried to streams by soil erosion. Conservation practices can reduce the chances of nutrients polluting waterways.

Liquid manure should not be spread within 10 m (33 ft) of a watercourse (5 m for solid manure).

Flow in tile drains can become contaminated if manure enters a catch-basin or travels through soil cracks to the tiles. With liquid manure, maintain a 30-foot buffer around a catch-basin or surface inlet (15 ft with solid manure). If there is any history of tile contamination via soil cracks or macropores, tillage prior to application is recommended.

Applications of nutrients in manure or fertilizer in excess of crop requirements can result in the contamination of groundwater, particularly on shallow soils over bedrock, soils with a water table close to the surface or very sandy soils where leaching is a concern. Groundwater contamination can occur by mass flow through cracks and holes to groundwater or through leaching of nitrates through the soil.

Food Safety Concerns with Manure

Fruit and vegetable crops can become contaminated in the field if they contact microbes that cause human illness. These microbes can come from manure fertilizers and manure-based composts. They can contaminate fruit or vegetables by direct soil-to-produce contact or through rain-splashed soil. Examples of harmful microbes are some, but not all, strains of *E. coli, Salmonella* and *Campylobacter.*

The longevity of harmful microbes in manure is not well known. Proper composting of manure, which results in heating to a specific temperature for a specified period of time, will reduce the level of most pathogens. Aged manure (manure stored in piles and occasionally turned) may contain considerably more pathogens than properly composted manure (manure turned/mixed frequently, temperature monitored and maintained). Composting may not completely eliminate all pathogens, so the appropriate precautionary measures should be taken when manure is used. Incorporation of manure will minimize but may not eliminate the risk of microbial contamination of produce.

TABLE 3–12.
Fertilizer Materials — Primary Nutrients

Nitrogen Materials	Form	% Nitrogen (N)
Ammonium nitrate	Dry	33 to 34
Urea	Dry	45 to 46
Ammonium sulfate	Dry	20
Calcium ammonium nitrate	Dry	27
Calcium nitrate	Dry	15.5
Aqua ammonia	Liquid[1]	20
Urea ammonium nitrate (UAN)	Liquid	28
Anhydrous ammonia	Liquid[1]	82
Phosphate Materials		**% Phosphate (P_2O_5)**
Single superphosphate		20
Triple superphosphate		44 to 46
Monoammonium phosphate		48 to 52
Diammonium phosphate (18-46-0)		46
Potash Materials		**% Potash (K_2O)**
Muriate of potash		60 to 62
Sulfate of potash		50
Sulfate of potash magnesia (11% Mg)		22
Potassium nitrate (13-0-44)		44

[1] Liquid under pressure

Manure application to vegetable crops is not recommended before harvest, in the year of harvest.

Fertilizer Materials

Nitrogen fertilizer materials are available in dry or liquid forms. Although there are some limitations to the use of these materials (see the section *Toxicity of Fertilizer Materials* on page 32), in most cases, the different sources will produce equal yields. The grower's choice of material should therefore depend on availability, equipment for handling and cost per kilogram of nitrogen, plus the cost of application.

The grower should first calculate the cost per kilogram of nitrogen from various sources delivered to the farm. Using the rate of application, the cost per hectare can be determined. Add the cost of application per hectare before deciding which nitrogen source to use.

Where separate additions of nitrogen are referred to in the recommendations, kilograms of elemental nitrogen (N), not kilograms of materials, are used. Table 3–12, *Fertilizer Materials — Primary Nutrients*, and

TABLE 3–13.
Fertilizer Materials — Secondary and Micronutrients

A number of micronutrients are available as chelates, with various formulations and nutrient contents. Check the product labels. The effective use rate for chelated products is the same as for other formulations.

Calcium (Ca)	
Calcium chloride	36% Ca
Calcium nitrate	19% Ca
Liming materials and gypsum also supply calcium	variable %
Magnesium (Mg)	
Dolomitic limestone	6–13% Mg
Epsom salts (magnesium sulfate)	10.5% Mg
Sulfate of potash magnesia	11% Mg
Boron (B)	
Sodium borate	12–21% B
Copper (Cu)	
Copper sulfate	13–25% Cu
Copper chelates	5–13% Cu
Manganese (Mn)	
Manganese sulfate	26–28% Mn
Molybdenum (Mo)	
Sodium molybdate	39% Mo
Zinc (Zn)	
Zinc sulfate	36% Zn
Zinc chelates	7–14% Zn
Zinc oxysulfate	18–36% Zn

Table 3–13, *Fertilizer Materials — Secondary and Micronutrients*, above, show the percentage of fertilizer nutrient contained in different materials.

In addition to the micronutrient sources listed in Table 3–8 on page 26, various fertilizer companies sell pre-mixes containing one or more micronutrients.

Soluble Salts in Farm Soils

High concentrations of water-soluble salts in soils can prevent or delay germination of seeds and can kill established plants or seriously retard their growth.

Ontario field soils are naturally low in soluble salts. Soluble salts therefore rarely cause a problem in crop production and are not routinely measured in soil tests. Vegetable transplants, however, routinely experience salt problems. Symptoms resemble damping-off and/or uneven seedling growth.

Soluble salts in soils can result from excessive applications of fertilizers and manures, runoff of salts applied to roads

and chemical spills on farm land. High concentrations of soluble salts in or near a fertilizer band can cause serious early plant growth problems without seriously affecting the salt concentrations in the remainder of the soil. A given amount of salt in a soil provides a higher salt concentration in soil water if the amount of water is small. Soluble salts also interfere with the uptake of water by plants. For these reasons, plant growth is most affected by soluble salts in periods of low moisture supply (during drought periods).

Soluble salts can be measured readily in the laboratory by measuring the electrical conductivity of a soil water slurry. The higher the concentration of water-soluble salts, the higher the conductivity. Table 3–14, *Soil Conductivity Reading Interpretation,* right, provides an interpretation of soil conductivity reading as read in Ontario field soils in a 2:1 (water:soil paste) procedure used by the OMAFRA-accredited soil testing program.

For greenhouse soils, the OMAFRA-accredited soil test uses a larger soil sample and measures conductivity on a saturation extract. For greenhouse crops using this method, conductivity readings up to 3.5 millisiemens/cm are acceptable.

Toxicity of Fertilizer Materials

All fertilizer salts are toxic to germinating seeds and to plant roots if applied in sufficient concentration near the seed. Fertilizers vary in toxicity per unit of plant nutrient due to:

- differences in the amount of salts contained in the fertilizer per unit of plant nutrient
- differences in solubility of the salts in the soil
- a few specific materials or elements are particularly toxic (for example, ammonia and boron)

Nitrogen Fertilizers

Ammonium nitrate, monoammonium phosphate and ammonium sulphate are similar in toxicity and much safer than anhydrous ammonia, aqua ammonia or urea. Diammonium phosphate is more toxic than monoammonium phosphate but less toxic than urea. More care should be taken, particularly with sensitive seeds and on coarse-textured soil (sand and sandy loam), than is required with ammonium nitrate or monoammonium phosphate.

Because anhydrous ammonia and aqua ammonia are extremely toxic fertilizers, they should not be placed near seeds. It is preferable to make preplant applications crossways to the direction in which the crop will be planted.

TABLE 3–14.
Soil Conductivity Reading Interpretation

Conductivity "Salt" Reading millisiemens/cm	Rating	Plant Response
0–0.25	L	Suitable for most plants if recommended amounts of fertilizer are used.
0.26–0.45	M	Suitable for most plants if recommended amounts of fertilizer are used.
0.46–0.70	H	May reduce emergence and cause slight-to-severe damage to salt-sensitive plants.
0.71–1.00	E	May prevent emergence and cause slight-to-severe damage to most plants.
Greater than 1.0	E	Expected to cause severe damage to most plants.

Urea is toxic when banded with or near the seed but is safe when broadcast at rates normally used. Fertilizers containing more than half as much nitrogen as phosphate frequently contain urea.

Phosphate Fertilizers

Phosphate fertilizers are usually low in toxicity because a large portion of the phosphate is precipitated in the soil before it can reach the plant roots. The concentration of phosphorus in soil solution at any one time is very low. No limit is normally set for the safe rate at which phosphates may be applied with, or near, the seed of field-grown crops.

Diammonium phosphate is more toxic than other phosphate fertilizer. (See the section *Nitrogen Fertilizers,* left.)

Potash Fertilizers

Muriate of potash (KCl) is the most common source of potassium in fertilizers and is less toxic per unit of plant nutrients than most nitrogen fertilizers.

Sulphate of potash (K_2SO_4) is less toxic than muriate of potash.

Sulphate of potash-magnesia has approximately the same toxicity per unit of potassium as muriate of potash.

Potassium nitrate is one of the safer sources of potassium.

Fertilizers Containing Micronutrients

Fertilizers containing micronutrients (boron, copper, iron, manganese or zinc) are more toxic than the same grades without micronutrients, and maximum safe rates

should be reduced. Boron is particularly toxic and should not be banded.

Guidelines for Safe Rates of Nutrients Applied at Seeding

Fertilizer toxicity varies widely, depending on the amount of soil moisture. To ensure completely safe rates of banded fertilizer for all seeding conditions would require extremely low rates of application. The maximum safe rates suggested here will probably reduce or delay germination, or retard growth in up to 10% of the cases where they are used. In most cases, it is advisable to use lower rates of fertilizer at seeding. If fertilizer requirements are high, it may be better to broadcast most of the fertilizer required and to band only a small portion at seeding. Fertilizers containing the micronutrients boron, copper, iron, manganese and zinc are more toxic, and the safe rates recommended will be lower than those shown in the tables.

Fertilizer Placement

Phosphorus is most important for early growth and is more available if placed near the seed. For transplant crops, the use of high-phosphorus starter solution is a profitable practice.

Nitrogen fertilizers readily dissolve in the soil water and move easily through the soil to the plant roots. Placement of nitrogen is less important than for phosphorus. Part of the nitrogen requirement is usually broadcast, injected or worked into the soil before planting, often to hasten the breakdown of the cover crop. In some instances, a good portion of the nitrogen is not applied until side-dressing in order to minimize leaching or to restrain plants from too much vegetative growth.

Too much potassium applied in a band at planting or in the transplant water can injure young seedlings and reduce crop yield and quality. The danger of fertilizer injury is greater on sands and sandy loams than on silt loam and clay loam soils. On the coarse textured sand and sandy loams, part of the potassium fertilizer requirements should be broadcast and worked into the soil before planting.

Starter Solutions

Water-soluble fertilizers (e.g., 10-52-10) and liquid fertilizers (e.g., 6-24-6 and 10-34-0) are used as starter solutions at planting time to stimulate the growth of young transplants.

Vegetable crops will benefit if starter solutions are used in the planting water when the young transplants are set in the field.

Mixtures or combinations of micronutrients in the starter can cause problems for transplants, particularly under adverse weather conditions.

Side-Dressing

The purpose of side-dressing is to supply additional nutrients during the growth of the crop. Most commonly, nitrogen is the nutrient that is supplied after the plant has reached a certain stage of development. With crops that produce fruit (e.g., peppers or tomatoes), it is important not to have too much vegetative growth early in the season, or flowers will not develop or may drop off if they do develop. For this reason, it is usually advisable to put only a moderate amount of nitrogen in the soil at the time of seeding or planting.

After the plant has set some fruit and is no longer in danger of becoming too vegetative, extra nitrogen can be applied. The timing and amount of nitrogen side-dressing must be judged from the appearance of the plants. On coarse, sandy soil it may be advisable to add potash as well as nitrogen.

Foliar

Micronutrients can be supplied to the crop through foliar fertilization, particularly in instances where a deficiency is due to a tie-up of these nutrients in the soil. Quantities of nutrient that can be applied this way are limited because of the danger of burning the leaves. Care must be taken when combining nutrients that the resulting solution is not too concentrated. Check pesticide labels before mixing foliar nutrients with any pesticide spray.

Fertilizer Through the Irrigation System

Many fertilizers, particularly nitrogen, may be applied through the irrigation system during the growing season. In some crops, it is difficult to move along the rows with side-dressing machinery without damaging the plants, whereas the irrigation water will penetrate fairly evenly over the whole area without damaging the plants. See the section *Irrigation* on page 43 for more information.

For more information, consult OMAFRA Publication 611, *Soil Fertility Handbook*.

Managing Soil Organic Matter

Most of the prime vegetable-growing soils are light in texture. Vegetable production tends to be a very intensive process, usually involving a lot of tillage. Maintaining soil organic matter levels is a challenge and an ongoing process. Soil organic matter helps to maintain soil structure, enhances soil moisture-holding capacity, increases the soil's ability to hold nutrients and improves drainage. Maintaining adequate soil organic matter levels can help to maintain crop yields, particularly in years of adverse weather.

Increasing soil organic matter is a slow process, since only a small part of the organic matter added to the soil ends up as stable humus. It is therefore important to keep as much organic matter in the soil as possible by reducing soil erosion and eliminating unnecessary tillage passes. Organic matter additions will also, over time, increase the total soil organic matter. These may be in the form of livestock manures, biosolids, forage crops or cover crops. Manure and biosolids are discussed in a previous section. Rotation plays a key role in maintaining soil organic matter. Vegetable crops typically return very little residue to the soil. Try to rotate vegetable crops over a period of 3–4 years with other field- or soil-improving crops that leave more residue. Sometimes this is not possible for a variety of reasons. It is very important to take every opportunity to use green manure and cover crops to build and protect the soil.

Subsidence of Peat and Muck Soils

Cultivated peat and muck soils decompose or subside (oxidize) gradually at rates of 1–3 cm/yr. Maintaining a high water table and a low pH reduces the rate of subsidence to less than 0.05 cm/yr. See the OMAFRA Factsheet, *Management of Organic Soils*, Order No. 98-077, for more detailed information on water control and recommended heights of water table for vegetable crops. A very wet (or very acidic) soil does not give maximum yields and is likely to be flooded when rainfall is intense. Wet spots may also be difficult to work and result in uneven crop growth. Research has shown that copper (Cu) applied as fertilizer has the residual effect of slowing down degradation, and thus subsidence, by about 50%. Apply 14 kg of Cu/ha annually to peats and mucks in the first 3 years of cultivation and up to 5 kg of Cu/ha every second year thereafter, particularly when onions, carrots or lettuce are grown on the soils.

Cover Crops

Adaptation and Use of Cover Crops

Cover crops play a major role in Ontario by providing ground cover to reduce erosion and adding organic matter to improve the soil. Following is information on some of the more commonly used cover crops. See also Table 3–15, *Characteristics of Cover Crops Grown in Ontario*, on page 35.

Grasses

Grasses have fine, fibrous root systems that are well suited to holding soil in place and improving soil structure. Suitable grass species for cover crops are fast growing and relatively easy to kill, either chemically, mechanically or by winter weather. Grasses do not fix any nitrogen out of the atmosphere, but they can accumulate large quantities from the soil.

Ryegrass (Annual, Italian or Perennial)

Ryegrass is planted from direct seed in spring or from August to mid-September, or by seed with a nurse crop in spring. It has also been broadcast into corn in late June–early July with some success. Annual ryegrass gives the most top growth on the seeding year, often heading 6–8 weeks after seeding. Italian ryegrass (a biennial) does not head on the seeding year, so top growth is considerably less. However, it has the largest, densest root system of the three types. Annual and Italian ryegrasses usually suffer considerable winterkill, but part of the stand may survive. Perennial ryegrass normally survives the winter.

Cautions: Establishment and growth of ryegrasses can be poor during very hot, dry weather. It can be difficult to kill overwintering ryegrass with only cultivation or discing. The nitrogen tied up in ryegrass releases more slowly than from many other cover crops. Thus corn after ryegrass often requires an extra 20–30 kg/ha of nitrogen.

Spring Cereals

Spring cereals are usually seeded for plowdown. Stands seeded from mid-August to mid-September will have 20–40 cm of growth by freeze-up. The stand is generally killed by late, hard frosts.

Volunteer spring cereals are sometimes left to grow until freeze-up as a cover crop. Stands may not be very uniform. There may be up to 70 cm of growth by freeze-up, resulting in a heavy mat that keeps the soil wet the following spring. On erosion-prone knolls, spring cereals often have little growth and have been

TABLE 3–15.
Characteristics of Cover Crops Grown in Ontario

Species	Normal Seeding Time	Seeding Rate kg/ha	Nitrogen Fixed	Overwintering Characteristics	Potential Weed Problem from Volunteer Seed	Nematode Rating [1]	
						Lesion	Root-knot
Grasses							
Ryegrass	April to May or August to early September	12–18	no[2]	Annual, Italian; partial survival	no	–	–
Spring cereals	Mid-August to September	100–125	no	Perennial; overwinters killed by heavy frost	no	+	–
Sorghum sudan	June to August	50	no	killed by frost	no	NH	–
Winter rye	September to October	100–125	no	overwinters very well	no	+[3]	–
Legumes[4]							
Hairy vetch	August	20–30	yes	overwinters	no	++	+
Red clover	March to April	8–10	yes	overwinters	no	++	+++
Sweet clover	March to April	8–10	yes	overwinters	no	–	–
Non-Legume Broadleaves							
Buckwheat	June to August	50–60	no	killed by first frost	yes	+++	NH
Oilseed radish[5]	Mid-August to early-September	10–14	no[2]	killed by heavy frost	yes	NH	NH

Nematode Rating Codes: – = poor or non-host + = ability to host NH = non-hosts

[1] Varietal differences in cover crop species may affect nematode reaction.
[2] Oilseed radish and ryegrass do not fix nitrogen from the air, but are strong accumulators of nitrogen from soil and manure applications.
[3] Rye — whole season rating would be higher (+++).
[4] Some diseases like *Pythium* and *Phytophthora* can be more severe after legume cover cropping.
[5] Oilseed radish residues can be toxic or allelopathic to subsequent crops if the following crop is planted too closely after green manuring. Allow the green manure residues to break down or dessicate before planting the next crop.

observed to "blow off" by spring and may open the whole field to more erosion.

Cautions: Early seeding may result in considerable growth by freeze-up. If left unplowed in the fall, the mat of dead residue will slow soil drying and warming in the spring, which can cause problems in early-seeded crops.

Sorghum Sudan

Sorghum sudan is an excellent choice for growing as a green manure crop for soil improvement. The root growth is extensive and the top growth lush. A pre-plant herbicide treatment is recommended for crop establishment. Plant after all threat of frost is past in mid-June. The crop will benefit from the warm temperatures of early to mid summer. Approximately 50 kg/ha of N will help the crop achieve maximum top growth.

Cautions: Sorghum sudan should be mowed before it reaches the height of 1 m, in order to encourage tillering and to ensure that stalks are not woody and will break down readily.

Winter Rye

Winter rye is seeded from September into mid-October, often following vegetable crops. It grows until freeze-up, and then commences growth again in late March to early April (slightly earlier than winter wheat). Growth rate is very rapid during May. The stand is generally killed in late April or early May by tillage or herbicide use.

Winter rye can be seeded later than any other crop and still survive over winter. For good ground cover and erosion protection, it should be seeded at least a month before freeze-up. Winter rye is one of the most consistent, flexible and economical cover crops available.

Cautions: Rye will grow very rapidly under warm temperatures in early spring. Monitor growth to kill it at an appropriate time. It can deplete soil moisture, and incorporation can be difficult if it is allowed to grow too tall.

Winter Wheat

Winter wheat can be seeded in late August through October. It can be seeded outside this time frame, however, weather conditions may reduce top growth. Wheat will survive overwinter and begin growing in April. The stand can be killed through tillage or herbicide application. The plant shuts down earlier in the fall and begins to grow later in the spring than rye.

Cautions: Generally, winter wheat does not provide the same amount of green material to return to the soil or the level of weed competition that rye provides.

Legumes

Legume cover crops can fix nitrogen from the air, supplying nitrogen to the succeeding crop as well as protecting the soil from erosion and adding organic matter. The amount of nitrogen fixed varies between species, although, generally, more top growth equals more nitrogen fixed. Some legume species have aggressive tap roots that can break up subsoil compaction, but this requires more than one year's growth to happen.

Nitrogen release from legumes can be inconsistent. This must be accounted for when calculating your fertilizer needs. Excess nitrogen release late in the season could lead to excess vegetative growth or split set in tomatoes.

Hairy Vetch

To provide good ground cover over winter, hairy vetch must be seeded by mid-August. It grows slowly until freeze-up and establishes a very vigorous, fibrous root with moderate top growth. Hairy vetch may also be drilled into winter wheat when the wheat is about 20 cm tall. Seeding at this later stage prevents the hairy vetch from causing a problem with wheat harvest, but results in much more vetch growth by freeze-up than August seedings.

The vines resume growth early in the spring (similar time to winter wheat) and may reach 150 cm in length if left to maturity. Plowdown stands are usually killed in the spring by tillage or herbicide application. Vetch's fibrous root system improves soil structure, and large amounts of fresh organic matter are added to the soil.

Cautions: Competition from volunteer cereals can lead to poor stands of hairy vetch. On droughty soils, hairy vetch left alive until early May may deplete soil moisture. Round-up is not effective in killing hairy vetch; 2,4-D, MCPA, Banvel or their mixtures should be used. If hormone-sensitive crops are following, apply hormone sprays in the fall to avoid injury.

Red Clover

Red clover is commonly broadcast into winter wheat in March or early April or seeded with spring cereals. Early seeding gives best stands. Double-cut red clover produces considerably more top growth than single cut (60 cm versus 25 cm, respectively). For plowdown, common seed produces equal results to pedigreed seed, although it may contain more weed seeds.

Major growth takes place from grain harvest until a heavy frost. Red clover can be killed in the fall or the spring by tillage or herbicide application. Unless herbicides are also applied, chisel plowing will not kill the stand completely.

Red clover plowdown improves soil structure and adds large amounts of fresh organic matter. Nitrogen is fixed and released slowly to the following crop. It gives excellent erosion protection when left unplowed until spring or killed in the fall with a herbicide.

Cautions: Round-up alone is often not effective in killing red clover; consider 2,4-D, MCPA, Banvel or mixtures. If hormone-sensitive crops are following, apply hormone sprays in the fall to avoid injury.

Sweetclover

Sweetclover is most commonly seeded into winter wheat in March or early April or seeded with spring cereals. Either yellow- or white-blossom type may be used. White-blossom type produces somewhat taller top growth. Major growth takes place after the grain is harvested until heavy frosts. Top growth will usually be 30–40 cm tall, but not dense. A strong taproot is produced, often 30 cm long and 1 cm across at the crown. If allowed to grow the following spring, sweetclover will flower in July at a height of about 180 cm, set seed and die. Plowdown stands may be killed in the fall or the following spring by tillage or with herbicides.

Cautions: Sweetclover is very sensitive to many herbicides and will not tolerate any phenoxy herbicides, including 2,4-D.

Non-Legume Broadleaves

These broadleaf crops cannot fix nitrogen out of the air, but they may absorb large quantities from the soil. Neither of these crops are winter-hardy, so additional control measures are not normally required, but they

should not be allowed to go to seed, as the volunteer seed can become a significant weed problem.

Buckwheat

As a cover crop, buckwheat is most commonly seeded in late June to early August. It grows very rapidly, reaching flower stage and a height of 45–75 cm in about 6 weeks. It has a relatively small fibrous root system and is completely killed by the first frost.

Buckwheat provides rapid soil cover, gives good erosion protection during the growing season, smothers annual weeds and suppresses perennial ones. Moderate amounts of fresh organic matter are returned to the soil. Buckwheat does not fix nitrogen.

Cautions: Late summer seedings may be killed by an early frost before providing significant growth.

Oilseed Radish

Oilseed radish is commonly seeded in August or very early September. It is unaffected by early frosts and can grow to a height of 50–90 cm and bloom in October. The plant has a thick but short taproot, varying between carrot and turnip shaped. It is killed by severe frosts in late November or December. It gives a reasonably rapid soil cover and excellent erosion protection over winter and returns moderate amounts of organic matter to the soil. For good growth, this crop must have a large amount of available nitrogen, either from a recent manure application or from nitrogen left from a previous crop.

Cautions: Growth will be poor if soil nitrogen levels are low. Scattered volunteer plants usually appear in the following crops.

Tillage Systems After Cover Crops

Cover crops reduce soil erosion potential by keeping the ground covered between crops, by improving soil structure and, in conservation tillage systems, by increasing surface residue cover.

Management factors to consider when reduced tillage follows cover crops are:

- Some regrowth of winter annual, biennial or perennial cover crops will occur in the following crop year. Usually this is easily controlled with normal herbicide treatments in the following crop. A controlled amount of regrowth can provide some spring wind protection.
- The first mulch tillage operation with overwintering cover crops should occur at least 2 weeks prior to planting to allow the breakdown of the residue to start.
- It may be difficult to prepare a seedbed if persistent cover crops are not tilled until spring and are allowed to grow too large.
- Cover crops that do not survive over winter may be an option, especially on more poorly drained soils or for crops that are planted very early in the spring.
- Burndown herbicides should be considered before mulch tillage of overwintering cover crops such as rye. Careful timing and application of herbicides can help keep enough residue on the surface to prevent wind damage to tender crops while allowing crop establishment.

Water Quality

Water is a valuable resource. A clean and abundant supply of water is critical to the success of the farm business and the health of your family. Water is also shared by others, including fish and wildlife. Growers have a right to expect an ample supply of clean water, and it is their responsibility to ensure that the water leaving the farm is abundant and clean for the next user.

Farm operations impact water quality in many ways. Surface water quality can be affected by soil erosion, manures, septic system effluent, milkhouse wastes, fertilizers, pesticides and fuels. Groundwater quality can be affected by nutrients, manures, pesticides and fuels moving down through the soil into the groundwater.

The greatest water quality challenges affecting farmers involve bacteria (mostly from manures), nitrates, phosphorous and sediment. Pesticide contamination is much less of a problem. Problems can be minimized using the following practices:

Bacterial Contamination

- Contain run-off from manure storages, livestock yards, silos and cull piles.
- Avoid spreading manure on frozen or snow-covered ground.
- Make sure wells are properly maintained and protected from surface contamination.
- Properly treat or store milkhouse waste water.
- Ensure that the domestic septic system is working properly and is not discharging into a drainage system.

Soil Erosion

- Adopt the conservation tillage practices outlined earlier in this section.

M121

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- Install erosion-control structures.
- Use cover crops and wind-abatement crops.

Nitrate Contamination

- Complete and follow a nutrient management plan for the farm.
- Avoid spreading excessive amounts of manure or fertilizer on a field.
- Where a lot of manure and forages are used, the nitrate soil test can help to determine nitrogen requirements.
- Reduce nitrogen fertilizer when the previous crop was a legume or when manure was applied.

The following booklets from OMAFRA, Agriculture & Agri-Food Canada and the Ontario Federation of Agriculture contain more information on water quality problems and solutions, soil conservation measures and nutrient and manure use:

- *Best Management Practices: Water Management*
- *Best Management Practices: Field Crop Production*
- *Best Management Practices: Nutrient Management*
- *Best Management Practices: Pesticide Storage, Handling & Application*
- *Best Management Practices: Water Wells*

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- *Best Management Practices: Water Wells*

4. Vegetable Production Practices

Climate

Most vegetable production is concentrated in Southern Ontario. There are differences in climate even in this small area, particularly in the length of the growing season and in average temperatures.

Figure 4–1, below, is a climate zone map of Ontario. Zone A, in the Leamington-Harrow-Amherstburg area bordering on Lake Erie, has the longest growing season and is the smallest region. The other zones are progressively shorter in growing season. (The zone lines are approximate and do not represent sharp changes in climate.) The gradation of temperature and growing season from one zone to another is gradual.

Table 4–1, *Average Frost-Free Period in Climatic Zones of Ontario*, on page 40, gives approximate growing periods for tender crops and average dates of first and last frost (0°C) in each zone. These average frost dates are approximate guides to the beginning and end of the frost-free period in 5 out of 10 years. For example, in past records from Zone C, the last spring frost still occurred later than May 11 or the first fall frost occurred before October 6, in 5 out of 10 years. This 5-out-of-10 risk level may be excessive for planning many farm operations, so frost dates with lower risk levels may be determined as follows. Three years in 10, the first frost will occur about one week later in the spring or one week earlier in the fall than the date given in Table 4–1. For the 1-year-in-10

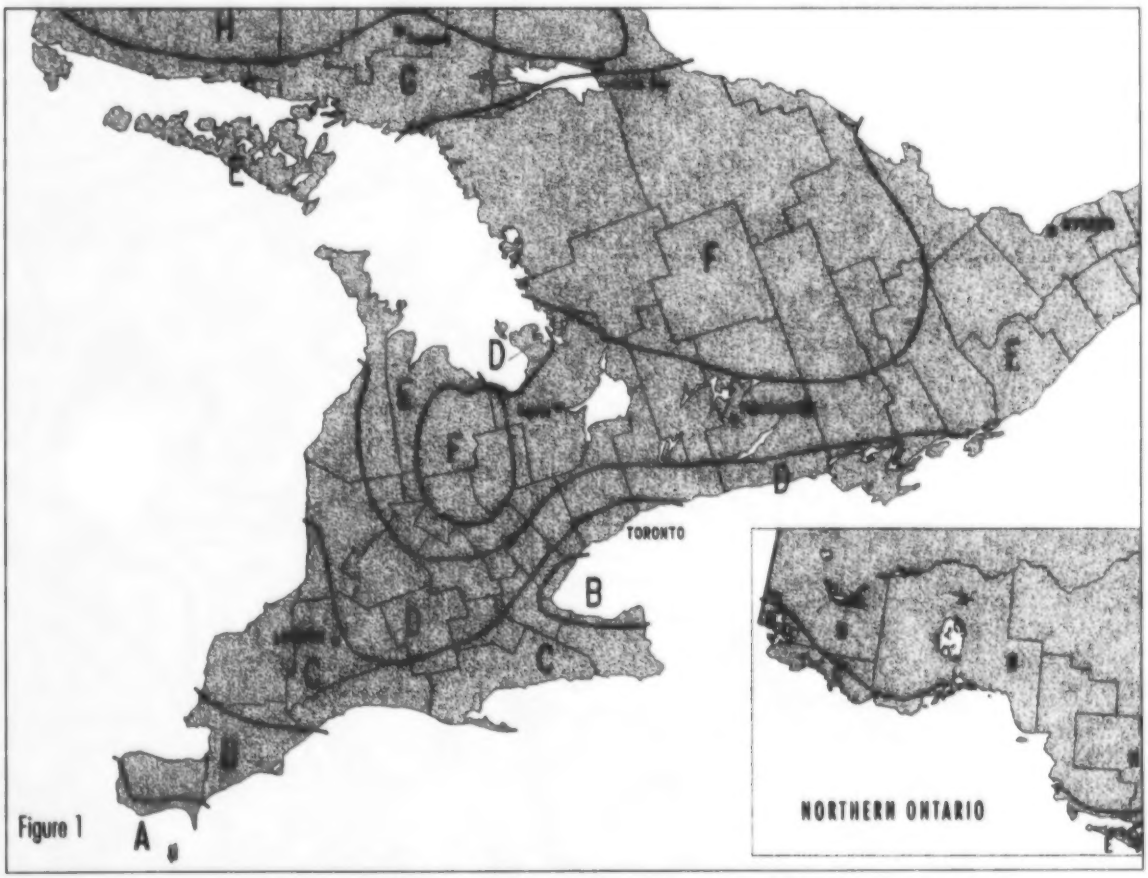

FIGURE 4–1. Climatic Zone Map of Ontario

TABLE 4–1.
Average Frost-Free Period in Climatic Zones of Ontario

Zone	Frost-free period (average in days)	Average date of last spring frost	Average date of first fall frost
A	180	April 25	October 25
B	165–180	May 5	October 15
C	145–165	May 10	October 10
D	130–145	May 18	October 2
E	120–135	May 22	September 28
F	105–120	May 31	September 20
G	100–120	May 25	September 15
H	100 or less	After May 25	Before Sept. 15

risk, the dates in Table 4–1 should be adjusted about 2 weeks later in spring and 2 weeks earlier in fall. For example, 1 year in 10, the last spring frost in Zone C has occurred later than May 25 or the first fall frost has occurred earlier than September 24.

Table 4–1 and the preceding paragraph refer to the occurrences of 0°C at a standard height of 1.5 m, at which time tender crops will often be damaged. Frost-hardier crops are not usually damaged until temperatures at this level drop below –2°C. The date of occurrence of –2°C is usually about 2 weeks earlier in the spring or later in the fall than the date of 0°C.

It is obvious that there are many local variations due to topography, altitude, natural air drainage and nearness to water that influence growing conditions. Cold air tends to flow, like water, into low-lying areas. Plants may be damaged by frost at the bottom of a slope and not have been injured on the slope or at the top of the hill.

Particularly in the spring, a south-facing slope or an area surrounded by a windbreak will be warmer than an unprotected area. These local variations must be considered in deciding the location of a planting or the time of planting.

Table 4–2, *First Field Seeding or Planting Dates for Commercial Production,* above, gives approximate first seeding or planting dates for common vegetable crops. Dates are given for Zones A, C and E. Planting dates for the other zones fall between these dates. These dates are a guide for seeding, but seasons will have to be taken into consideration. Long-term weather predictions can be helpful in deciding whether to seed earlier or later than the dates given. For many crops, the soil temperature is very important in determining the rate of early growth.

TABLE 4–2.
First Field Seeding or Planting Dates for Commercial Production

Crops	Zone A	Zone C	Zone E
Frost Hardy	April 1–15	April 15–25	April 25–May10
asparagus broccoli Brussels sprouts cabbage lettuce onions (set, seed, Spanish) radish rhubarb pea spinach parsnip early potato			
Semi-Frost Hardy	April 15–25	April 25–May 10	May 5–15
beet carrot cauliflower celery late potato early sweet corn			
Semi-Frost Tender	May 1–15	May 15–25	May 25–June 5
snap bean sweet corn tomato			
Frost Tender	May 20–30	May 25–June 5	June 5–15
lima bean cucumber eggplant muskmelon pepper pumpkin squash watermelon			

For this reason, even if air temperatures are high, if the soil has not yet warmed up, planting should be delayed somewhat.

Seeding Practices

Plant Population and Precision Seeding

Each crop should be spaced according to its optimum needs. (See Table 4–3, *Approximate Planting Depth and Seeds per Gram,* and Table 4–4, *Number of Plants per Hectare at Various Planting Distances,* on page 41 and Table 4–5, *Row Length per Acre or per Hectare at Various Row Spacings,* on page 42.)

Seeding carrots 2–4 cm apart in all directions eliminates most stress factors, resulting in uniform carrots relatively free from disease and misshapen roots. More than 8–12 rows of carrots per bed, at 4 x 4-cm spacing, will

TABLE 4–3.
Approximate Planting Depth and Seeds per Gram

Crop	Seeds per Gram	Seed Planting Depth (mm)	Crop	Seeds per Gram	Seed Planting Depth (mm)	Crop	Seeds per Gram	Seed Planting Depth (mm)
Asparagus	50	25	Collard	280	5	Parsley	550	5
Bean, snap	2–3	40	Corn	4–8	40	Parsnip	200	15
Bean, lima	1–3	40	Cucumber	40	20	Pea	3–6	25
Beet, Swiss chard	50	15	Eggplant	200	15	Pepper	150	5
Broccoli	320	5	Endive	500	5	Pumpkin	4	25
Brussels sprouts	280	5	Kale	270	5	Radish	125	15
Cabbage	300	5	Kohlrabi	280	5	Rutabaga	280	5
Chinese cabbage	250	5	Leek	350	15	Spinach	90	20
Carrot	900	5	Lettuce	700	5	Squash	10	25
Cauliflower	350	5	Melon	40	25	Tomato	350	5
Celery, celeriac	1,800	3	Mustard	550	5	Watermelon	10	25
Chicory	600	5	Onion	280	15			

prevent light from penetrating the foliage cover and adversely affect yield.

Lettuce seeded in beds and spaced 30 cm between plants produces more heads per unit of land, as well as a much higher percentage of marketable heads.

Onions sown in double rows 5–8 cm apart in and between the double rows, 4–6 double rows per bed, not only produce larger onions but much higher yields. The same can be said for many other crops. As plants reach the optimum spacing for their particular needs, growth improves and yields increase.

To obtain the optimum plant density, a system of precision seeding is needed. This system starts with the preparation of a fine, smooth seedbed, followed by uniform seeding at the same depth, at exact in-row and between row spacings. See the individual crop sections in Chapter 5, *Crop Management Recommendations*, starting on page 49, for spacing requirements.

With precision seeding, the harvested product will be more uniform in size and shape. Less effort will be required in grading and packing, and fewer culls will be obtained.

However, to achieve complete success with precision seeding, all factors — seed sizing, seed coating, high germination, uniform bed characteristics and uniform seeding depth — must be included. By omitting just one

TABLE 4–4.
Number of Plants per Hectare at Various Planting Distances

Row Spacing (cm)	Distance Within the Row (cm)						
	10	15	30	45	60	75	90
30	333,330	222,220	111,110	74,070	55,560	44,440	37,040
45	222,220	148,150	74,070	49,380	37,040	26,630	24,690
60	166,670	111,110	55,560	37,040	27,780	22,220	18,520
75	133,330	88,890	44,440	29,630	22,220	17,780	14,810
90	111,110	74,070	37,040	24,690	18,520	16,460	12,350
110	90,910	60,610	30,300	20,200	15,150	12,120	10,100
120	83,330	55,560	27,780	18,520	13,890	11,110	9,260

TABLE 4–1.
Average Frost-Free Period in Climatic Zones of Ontario

Zone	Frost-free period (average in days)	Average date of last spring frost	Average date of first fall frost
A	180	April 25	October 25
B	165–180	May 5	October 15
C	145–165	May 10	October 10
D	130–145	May 18	October 2
E	120–135	May 22	September 28
F	105–120	May 31	September 20
G	100–120	May 25	September 15
H	100 or less	After May 25	Before Sept. 15

risk, the dates in Table 4–1 should be adjusted about 2 weeks later in spring and 2 weeks earlier in fall. For example, 1 year in 10, the last spring frost in Zone C has occurred later than May 25 or the first fall frost has occurred earlier than September 24.

Table 4–1 and the preceding paragraph refer to the occurrences of 0°C at a standard height of 1.5 m, at which time tender crops will often be damaged. Frost-hardier crops are not usually damaged until temperatures at this level drop below –2°C. The date of occurrence of –2°C is usually about 2 weeks earlier in the spring or later in the fall than the date of 0°C.

It is obvious that there are many local variations due to topography, altitude, natural air drainage and nearness to water that influence growing conditions. Cold air tends to flow, like water, into low-lying areas. Plants may be damaged by frost at the bottom of a slope and not have been injured on the slope or at the top of the hill.

Particularly in the spring, a south-facing slope or an area surrounded by a windbreak will be warmer than an unprotected area. These local variations must be considered in deciding the location of a planting or the time of planting.

Table 4–2, *First Field Seeding or Planting Dates for Commercial Production*, above, gives approximate first seeding or planting dates for common vegetable crops. Dates are given for Zones A, C and E. Planting dates for the other zones fall between these dates. These dates are a guide for seeding, but seasons will have to be taken into consideration. Long-term weather predictions can be helpful in deciding whether to seed earlier or later than the dates given. For many crops, the soil temperature is very important in determining the rate of early growth.

TABLE 4–2.
First Field Seeding or Planting Dates for Commercial Production

Crops	Zone A	Zone C	Zone E
Frost Hardy	April 1–15	April 15–25	April 25–May10
asparagus broccoli Brussels sprouts cabbage lettuce onions (set, seed, Spanish) radish rhubarb pea spinach parsnip early potato			
Semi-Frost Hardy	April 15–25	April 25–May 10	May 5–15
beet carrot cauliflower celery late potato early sweet corn			
Semi-Frost Tender	May 1–15	May 15–25	May 25–June 5
snap bean sweet corn tomato			
Frost Tender	May 20–30	May 25–June 5	June 5–15
lima bean cucumber eggplant muskmelon pepper pumpkin squash watermelon			

For this reason, even if air temperatures are high, if the soil has not yet warmed up, planting should be delayed somewhat.

Seeding Practices

Plant Population and Precision Seeding

Each crop should be spaced according to its optimum needs. (See Table 4–3, *Approximate Planting Depth and Seeds per Gram*, and Table 4–4, *Number of Plants per Hectare at Various Planting Distances*, on page 41 and Table 4–5, *Row Length per Acre or per Hectare at Various Row Spacings*, on page 42.)

Seeding carrots 2–4 cm apart in all directions eliminates most stress factors, resulting in uniform carrots relatively free from disease and misshapen roots. More than 8–12 rows of carrots per bed, at 4 x 4-cm spacing, will

TABLE 4–3.
Approximate Planting Depth and Seeds per Gram

Crop	Seeds per Gram	Seed Planting Depth (mm)	Crop	Seeds per Gram	Seed Planting Depth (mm)	Crop	Seeds per Gram	Seed Planting Depth (mm)
Asparagus	50	25	Collard	280	5	Parsley	550	5
Bean, snap	2–3	40	Corn	4–8	40	Parsnip	200	15
Bean, lima	1–3	40	Cucumber	40	20	Pea	3–6	25
Beet, Swiss chard	50	15	Eggplant	200	15	Pepper	150	5
Broccoli	320	5	Endive	500	5	Pumpkin	4	25
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75	133,330	88,890	44,440	29,630	22,220	17,780	14,810
90	111,110	74,070	37,040	24,690	18,520	16,460	12,350
110	90,910	60,610	30,300	20,200	15,150	12,120	10,100
120	83,330	55,560	27,780	18,520	13,890	11,110	9,260

TABLE 4–5.
Row Length per Acre or per Hectare at Various Row Spacings

Distance Between Rows		Length of Row	
Imperial	Metric	Feet of Row/Acre	Metres of Row/Hectare
12 in.	30.48 cm	43,560	32,800
18 in.	45.72 cm	29,040	21,872
20 in.	50.8 cm	26,136	19,685
24 in.	61.96 cm	21,780	16,139
30 in.	76.2 cm	17,424	13,100
36 in.	91.44 cm	14,520	10,936
40 in.	1.016 m	13,068	9,842
42 in.	1.067 m	12,445	9,372
48 in.	1.219 m	10,890	8,203
60 in.	1.524 m	8,712	6,561
72 in.	1.829 m	7,260	5,467
84 in.	2.134 m	6,223	4,686
96 in.	2.438 m	5,445	4,102

factor, the results may be no better than with more conventional seeding methods.

The distance between rows will be determined by the method used to harvest the crop. Solid-bed planting can be done with some crops.

A precision seeder delivers the seed exactly where the final plant for harvest is to be grown. If this is accomplished, and the seed germinates normally, no thinning or transplanting will be required. Seed quality and seedbed uniformity will also determine the success of precision seeding.

Another important factor to consider is the kind of seed coat. Rough or angular seed like carrot and lettuce must be coated to a smooth, uniform shape with a water-absorbing material. Onions need to be coated to be successfully precision seeded.

Seeds that are naturally smooth and round, such as cabbage, cauliflower, radish and rutabaga, need only to be planted in batches of exactly the same size to provide uniform growth in the field.

Results with precision-seeding research in Ontario to date indicate that higher yields of better-quality vegetables are possible, regardless of when the crops may be grown.

Pre-germinated seed of most species will ensure more rapid emergence and may gain time or emergence over the slower, non-germinated seed. This can help the seed emerge before soil crusts form or weed seeds emerge.

Soils that are well drained and provide a good depth of permeable rooting volume are necessary. Impervious layers or a high water table can reduce the penetration of roots by excluding oxygen. Excessive moisture can be removed by tile drainage.

Plasticulture

Many vegetable crops, especially heat-loving crops such as cucurbits (vine crops), peppers, tomatoes, eggplant and sweet corn can benefit from the use of plastic mulch and row covers (plasticulture). Plasticulture can improve earliness, yield, fruit size and the quality of these crops. While plasticulture may be used with conventional fertilization and irrigation practices, growers should consider using drip (trickle) irrigation with fertilizer injection (fertigation) to maximize yield and quality. Plasticulture is more expensive than conventional production systems, but with good management, increases in yield and earliness will usually justify the additional cost.

Plastic Mulches

Plastic mulches raise soil temperature, control weeds, conserve soil moisture and maintain the soil in good tilth. There are many types of plastic mulches available:

- Clear plastic mulch provides the most soil warming because it transmits solar radiation directly to the soil (similar to greenhouses). However, weeds can grow under clear mulch and compete with the crop for water and nutrients. Clear mulch should only be used on crops where weeds can be controlled with preplant or post-emergent herbicides.
- Black plastic mulch absorbs solar radiation, then conducts heat to the soil surface. Soil warming is less efficient than with clear plastic, but black mulch suppresses weed growth. It is important that there is good soil-to-plastic contact in order to ensure maximum heat transfer. Black mulch is recommended for tomatoes and peppers.
- Wavelength selective or infrared transmitting (IRT) mulch combine the advantages of black and clear plastic. IRT mulch transmits certain light wavelengths that heat the soil directly but absorbs wavelengths that cause weed growth. This mulch material warms the soil more than black plastic, but less than clear. The disadvantages are that under cool temperature conditions, weed growth can occur under IRT mulch, and IRT mulches are more expensive than standard mulches. Research in Ontario has demonstrated that vine crops respond well to IRT mulches, but tomatoes and peppers do not.
- Photodegradable mulch is a type of plastic that breaks down after exposure to sunlight. This eliminates the need to pick up and dispose of mulch after the crop is completed. However, the timing of the breakdown is not consistent, and buried edges do not degrade, leaving portions of the mulch in the field. Most growers who have tried photodegradable mulches have gone back to standard mulches.

Several commercial plastic mulch layers are available. Proper soil preparation and set-up of the mulch layer is essential. The edges of the mulch should be well covered, and the plastic should be tight on the soil surface to permit heat transfer to the soil.

Mulch should not be laid on dry soil. If the soil is very dry, irrigate or wait for rainfall before laying. Soil moisture is required for plant growth and is important in holding heat.

Raised beds are not essential but will improve drainage and allow a tighter fit of the plastic to the soil surface. Pre-plant fertilizers and herbicides must be applied before the mulch is laid. Commercial transplanters are available to set transplants through plastic mulch.

Row Covers

Row covers can be used to make some crops produce earlier by increasing the canopy air temperature and protecting young transplants from wind damage. There are two basic types.

Floating Covers

These are made of polypropylene or various polyester-type fabrics and are laid directly over, and in contact with, the transplants. They are available in sheets up to 15 m wide to cover multiple rows of crops. Floating covers are well suited for vine crops and other low-growing plants. They are not recommended for use on upright-growing crops like tomatoes and peppers, because they can cause abrasion on the plant's shoot tips.

Mini Tunnels

These are made of white or clear polyethylene and are supported over the crop on wire hoops. The plastic usually has slits or perforations for ventilation. Commercial equipment that can install wire hoops, lay the plastic covers over the hoops and bury the edges of the row cover in one operation are available. Research in Ontario has demonstrated that use of mini tunnels can result in earlier production of peppers, cucumbers and melons. They are not recommended for use on fresh-market tomatoes, because fruit-set can be delayed in the tunnels. Evidence also exists that demonstrates such tunnels are good for early lettuce crops.

Regardless of the type of row cover used, heat can build up inside the covers and damage crops. Temperatures should be monitored, and the covers removed or ventilated when the temperature exceeds 32°C–35°C. For crops that require bee pollination (vine crops), row covers must be removed or opened up at flowering time.

Irrigation

Most vegetable crops require a uniform supply of moisture throughout the growing season. The average rainfall in Ontario is 70 mm/month during the growing season. This provides only 65% of the water needed for optimum yield. Soil types differ in their ability to retain water following rainfall or irrigation. Water that is held by the soil and can be taken up by plants is called "available soil moisture" (ASM). Sands and coarse sandy loams retain approximately 25 mm of ASM in the rooting zone of crops. Under average conditions, a crop will use this moisture in 7 days, so on these soils, a weekly irrigation of 25 mm of water would be required to maintain high

TABLE 4–6.
Classification of Vegetable Crops by Rooting Depth

Shallow-Rooted (down to 30 cm)	Intermediate (30–60 cm depth)	Deep-Rooted (deeper than 60 cm)
celery	broccoli	asparagus
lettuce	cabbage	parsnip
onion	carrot	pumpkin
potato	cauliflower	sweet corn
radish	cucumber	watermelon
	muskmelon	winter squash
	pepper	
	snap bean	
	tomato	
	zucchini	

yields. Fine sandy loams and silty loams retain 40–60 mm of ASM in the rooting zone. On these soils, heavier and less frequent irrigations (40–60 mm of water every 10–14 days) are required for optimum yields. Application of more water than is required wastes water and can cause leaching of fertilizers and herbicides.

Different vegetable crops also vary in their response to irrigation. Shallow-rooted crops such as potatoes and celery, require frequent, light irrigations. Deep-rooted crops can use water from a greater volume of the soil profile and do not require irrigation as frequently. Table 4–6, *Classification of Vegetable Crops by Rooting Depth*, above, shows the relative rooting depths of a number of vegetable crops.

In addition, most vegetable crops have growth stages during which drought stress can severely reduce yield and quality. Irrigation is especially important during these critical growth periods, listed in Table 4–7, *Critical Periods for Irrigation of Several Vegetable Crops*, above.

Also consult the OMAFRA Factsheet *How to Prepare for Irrigation During Water Shortages*, Order No. 99-023.

Note: You must have a "Permit to Take Water" issued by the Ministry of the Environment to use more than 50,000 litres of water in a day from either surface or groundwater sources for irrigation.

Irrigation Equipment

A number of different types of irrigation systems have been adapted for use in vegetable crops.

Hand-Moved Sprinklers

This is the least expensive overhead irrigation system, but the labour cost to move the laterals through the field is relatively high. Water distribution is very uniform, although tall crops are not easily irrigated.

TABLE 4–7.
Critical Periods for Irrigation of Several Vegetable Crops

Critical Period	Crop
Flowering, pod setting	snap bean
Head formation and enlargement	broccoli
	cabbage
	cauliflower
Tasseling, pollination, ear filling	sweet corn
Flowering, fruit set and development	cucumber
	muskmelon
	zucchini
Bulb formation and enlargement	onion
Flowering, fruit set and enlargement	eggplant
	pepper
	tomato

Travelling-Gun Systems

These systems are relatively expensive, but labour cost is reduced compared to hand-moved sprinklers. They are well suited to irrigating large fields and tall crops. Uniformity of water distribution is only fair and is greatly affected by wind.

Centre-Pivot and Lateral Systems

These are self-propelled systems located to move through and irrigate large fields from a centrally located well or pump. These systems are expensive, but labour costs through the season are low. They are adapted for use in large, relatively level fields.

Drip Irrigation

Drip irrigation systems consist of a series of built-in emitters in plastic tubing that is laid along the crop rows. Depending on the system, the emitters deliver from 1–5 L of water/hr and are spaced 30–60 cm apart. Drip irrigation is usually used in combination with plastic mulch and is best adapted for use in warm-season crops such as tomatoes, peppers and vine crops. The cost of installing a drip system is relatively high, but the labour cost through the season is very low. A major advantage of drip systems is that less water is required, and the crop has a more uniform water supply through the season.

Growers should contact their irrigation dealer for information about the cost of various systems and the design of the system to suit different crops and fields.

Irrigation Scheduling

Whichever type of irrigation system is used, it is important to use some method of irrigation scheduling to avoid drought stress and provide water when it is most needed. There are two basic methods of irrigation scheduling.

Tensiometers

Tensiometers are devices that measure the suction of the soil on moisture. As the soil dries out, moisture is more strongly held to soil particles and less available to the crop. Tensiometers can be used to determine when moisture stress occurs, and thus when irrigation should be started. Growers should consult their irrigation dealers on the use of tensiometers.

Water Budget Method

This method uses climatic data to estimate the amount of available water lost from the rooting zone through crop use and evaporation. The amount of crop water use is calculated using the percentage of crop cover and the evapotranspiration rate from climatic data. Further details of this method are provided in the OMAFRA Factsheet, *Irrigation Scheduling for Tomatoes — Water Budget Approach*, Order No. 90-049.

Other Uses for Irrigation

Irrigation systems may also be used to apply soluble fertilizers to the crop throughout the growing season. This is also known as fertigation. A stock solution of fertilizer can be dissolved in a tank and introduced through a valve into the irrigation system either by suction or pressure. The fertilizer solution should be fed through the system slowly, over 10–20 minutes. After the fertilizer has passed through the system, continue to irrigate for 10–15 minutes to flush the system and wash the fertilizer off the leaves. Some minor element deficiencies, such as boron, manganese or copper deficiency, may be corrected by the application of the appropriate fertilizer salts through irrigation systems. Drip irrigation systems may also be used to apply soil fumigants prior to planting the crop and for fertigation through the growing season. Sprinkler irrigation may be used for the evaporative cooling of crops during hot weather and for frost protection.

Drip (Trickle) Irrigation

Drip irrigation is an efficient method of irrigating vegetable crops grown on plastic mulch. The annual cost is comparable to or slightly higher than overhead irrigation, but drip requires less water and very little labour during the growing season. Crop yields are comparable or slightly higher than with overhead irrigation. If fertilizer injection is combined with drip irrigation, greater yield increases are possible.

A drip irrigation system consists of a filtration system, flow meter, pressure regulator, main line, header lines, and lateral lines with built-in emitters (drip tubing or tape). If fertigation is to be used, a fertilizer injector will also be required.

Growers should consult with a specialist at an irrigation company for information on designing a drip irrigation system.

Fertigation

Fertigation is a method of applying water and nutrients through a drip irrigation system and can be used to increase the yield and quality of many vegetable crops. Fertigation schedules will vary depending on crop and soil type, but the following general recommendations apply in most situations.

- Scheduling of nutrient injection is done according to crop demand. Therefore, low rates of nutrients are applied when the crop is small, and rates are increased during the period of rapid growth and fruit development.
- Soil tests should be used to determine phosphate and potash requirements. All the phosphate requirements should be broadcast prior to laying the mulch.
- Approximately 30–50% of the nitrogen and potash requirement should be broadcast prior to mulching, and the remainder should be injected through the drip irrigation system.
- Fertilizers to be injected through drip irrigation must be soluble in water. Greenhouse grade ammonium nitrate, potassium nitrate and calcium nitrate should be the primary nutrient sources. Soluble fertilizers such as 20-5-30 or 20-0-20 may be used, although they are more expensive than the greenhouse grade fertilizer materials.
- Fertilizer materials may be mixed together in one stock solution tank, or separate solutions may be prepared for each fertilizer and injected with a multi-head fertilizer injector. DO NOT mix fertilizers containing calcium with fertilizers containing phosphates or sulphates as these can precipitate out and plug emitters.
- Proper scheduling of drip irrigation is essential to avoid leaching of fertilizer. Tensiometers can be used to indicate when to irrigate and how much water to apply. Sandy soils are irrigated when soil moisture tension reaches 15–20 centibars and loamy soils at 20–25 centibars.
- The frequency of fertilizer injection can vary. A low rate of fertilizer could be injected every 1–2 days while higher rates could be injected every 5–7 days. More frequent injections are recommended on coarse sands, which do not retain moisture and nutrients well.
- Growers should consult with their irrigation supplier for information on fertilizer injectors.

TABLE 4–8.
Nitrogen and Potash Injection Schedules

Growth Stage	Rate of N and K_2O to Inject Per Week (kg/ha)		
	Vine Crops [1]	Peppers	Tomatoes
Transplanting to fruit set	5	3–5	2.5
Fruit sizing to harvest	10	7–10	5
Harvest	5	3–5	2.5

[1] Cucumbers, melons, summer squash.

- Table 4–8, *Nitrogen and Potash Injection Schedules,* above, contains nitrogen and potash injection schedules for vine crops, peppers and tomatoes grown on sandy loam soils. These rates can serve as a starting point and may be adjusted up or down depending on crop growth.

Storage

To preserve the quality of harvested vegetables and improve the marketing of crops, proper storage immediately after harvest is necessary. Rapid, uniform cooling to remove field heat followed by proper storage conditions will ensure that a quality product reaches the consumer or processor.

See Table 4–9, *Storage Life for Fresh Vegetables in Commercial Storage,* on page 47, for details on individual crops.

Ethylene

Ethylene is a gas that is naturally produced by most fruit and vegetables once harvested and put into storage. It acts as a growth regulator and a ripening agent. Ethephon is a synthetically produced ethylene product available commercially, widely used in the processing tomato industry (see the section *Chemical Fruit Ripening* on page 140).

For the most part, ethylene gas increases the rate of ripening of mature fruits and vegetables, and shortens their shelf life. The effects of ethylene gas depend upon the stage of produce maturity, the temperature and relative humidity of the storage room, the concentration of ethylene and the exposure time to ethylene.

Ethylene is an invisible and odourless gas, however, its detrimental effects on produce can be easily misdiagnosed. Some of the undesirable effects of ethylene are:

- loss of green colour in some immature fruits (for example, cucumbers and squash) and leafy vegetables
- accelerated ripening of fruits during handling and storage
- russet spotting on lettuce
- formation of bitter principle (isocourmarin) in carrots
- sprouting of potatoes
- abscission of leaves (for example, cauliflower, cabbage)
- toughening of asparagus

The sources of ethylene in the environment are many. The more important ones include internal combustion engines and ripening produce. Other sources include fluorescent ballasts, decomposing produce, cigarette smoke and rubber materials exposed to heat or UV light.

Use electric rather than gas-powered fork lifts where commodities are sensitive to ethylene. Isolate internal combustion engines from handling and storage areas. Do not let engines idle in an enclosed loading space.

Simple ventilation of handling areas can reduce the concentration of ethylene as long as the incoming air is not polluted. One air exchange per hour is usually sufficient.

Ethylene can be used to your advantage when controlled and careful ripening of fruits and vegetables is desired. In this case, commercially available ethylene generators are used.

Commodity Compatibility

Not all crops should be stored together, even if they have the same storage requirements. Some crops will give off volatile substances that are deleterious to the successful storage of others. For example, apples, pears, peaches, plums, apricots and tomatoes give off ethylene gas which, even in low concentration, can initiate sprouting of potatoes, carrots and onions, cause blanching and yellowing of leafy vegetables such as cabbage, lettuce, celery and Brussels sprouts and induce bitterness in carrots.

Therefore, these two groups should not be stored in the same room or even in the same building unless special ventilation requirements have been made. Potatoes may impart an earthy flavour to fruit, particularly at high temperatures.

Storage Tips

- Thermometers are not expensive. Have several in the storage area to help ensure the area is being uniformly cooled. Calibrate thermometers regularly to ensure that fresh produce is stored properly. Thermometers set into ice water should read 0°C.
- Change the wash water daily when washing fresh produce. This prevents the build-up of bacteria. This is of great importance during periods of warm weather. In addition, use chlorine at 150–200 ppm to help prevent rot from getting started. Swimming pool bleach is a good source of chlorine.

M121

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TABLE 4–9.
Storage Life for Fresh Vegetables in Commercial Storage

Commodity	Temperature °C	Relative Humidity (%)	Approximate Storage Life
Asparagus	0–2	95–100	2–3 weeks
Beans, green or snap	4–7	95	7–10 days
Beans, lima	3–5	95	5–7 days
Beets, topped	0	98–100	4–6 months
Broccoli	0	95–100	10–14 days
Brussels sprouts	0	95–100	3–5 weeks
Cabbage, Chinese	0	95–100	2–3 months
Cabbage, early	0	98–100	3–6 weeks
Cabbage, late	0	98–100	5–11 months
Carrots, bunched	0	95–100	2 weeks
Carrots, immature	0	98–100	4–6 weeks
Carrots, mature	0	98–100	7–9 months
Cauliflower	0	95–98	3–4 weeks
Celeriac	0	97–99	6–8 months
Celery	0	98–100	2–3 months
Chard	0	95–100	10–14 days
Chicory, witloof	0	95–100	2–4 weeks
Collards	0	95–100	10–14 days
Corn, sweet	0	95–98	5–8 days
Cucumbers	10–13	95	10–14 days
Eggplants	8–12	90–95	1 week
Endive and escarole	0	95–100	2–3 weeks
Garlic	0	65–70	6–7 months
Greens, leafy	0	95–100	10–14 days
Horseradish	–1.0–0	98–100	10–12 months
Kale	0	95–100	2–3 weeks
Kohlrabi	0	98–100	2–3 months
Leeks	0	95–100	3–6 months
Lettuce	0	98–100	2–3 weeks

Commodity	Temperature °C	Relative Humidity (%)	Approximate Storage Life
Melons			
Honey Dew	7	90–95	3 weeks
Muskmelon (¾-slip)	2–5	95	15 days
Muskmelon (full slip)	0–2	95	5–14 days
Watermelons	10–15	90	2–3 weeks
Mushrooms	0	95	3–4 days
Okra	7–10	90–95	7–10 days
Onion, dry	0	65–70	1–8 months
Onion, green	0	95–100	3–4 weeks
Onion, sets	0	65–70	6–8 months
Parsley	0	95–100	2–2.5 months
Parsnips	0	98–100	4–6 months
Peas, green	0	95–98	1–2 weeks
Peppers, chili (dry)	0–10	60–70	6 months
Peppers, sweet	7–13	90–95	2–3 weeks
Potatoes, chipping	10	90–95	10 months
Potatoes, early crop	4	90–95	7 days
Potatoes, late crop	4	90–95	5–10 months
Potatoes, seed	2–4	90–95	7 months
Potatoes, sweet	13–16	85–90	4–7 months
Pumpkins	10–13	50–70	2–3 months
Radishes	0	95–100	3–4 weeks
Rhubarb	0	95–100	2–4 weeks
Rutabagas	0	98–100	4–6 months
Salsify	0	95–98	2–4 months
Spinach	0	95–100	10–14 days
Squashes, summer	5–10	95	1–2 weeks
Squashes, winter	10	50–70	1–6 months
Sweet potatoes	13–16	85–90	4–7 months
Tomatoes, firm-ripe	8–10	90–95	4–7 days
Tomatoes, mature-green	13–21	90–95	1–3 weeks
Turnips	0	95	4–5 months

Fresh produce infected with bacteria will break down readily in storage even under cool conditions. The quality of the produce coming out of storage will reflect its quality going in.

Sanitation

Cleaning and sanitation in horticultural storage and packing areas is extremely important to eliminate disease-causing organisms. Cleaning is not the same as sanitizing. Cleaning includes removing debris, like soil, wood, stones and metal, by brushing, vacuuming, scraping and high-pressure washing. Cleaning compounds such as soaps can be used to lower the surface tension of water so that soils may be loosened and flushed away.

TABLE 4–9.
Storage Life for Fresh Vegetables in Commercial Storage

Commodity	Temperature °C	Relative Humidity (%)	Approximate Storage Life
Asparagus	0–2	95–100	2–3 weeks
Beans, green or snap	4–7	95	7–10 days
Beans, lima	3–5	95	5–7 days
Beets, topped	0	98–100	4–6 months
Broccoli	0	95–100	10–14 days
Brussels sprouts	0	95–100	3–5 weeks
Cabbage, Chinese	0	95–100	2–3 months
Cabbage, early	0	98–100	3–6 weeks
Cabbage, late	0	98–100	5–11 months
Carrots, bunched	0	95–100	2 weeks
Carrots, immature	0	98–100	4–6 weeks
Carrots, mature	0	98–100	7–9 months
Cauliflower	0	95–98	3–4 weeks
Celeriac	0	97–99	6–8 months
Celery	0	98–100	2–3 months
Chard	0	95–100	10–14 days
Chicory, witloof	0	95–100	2–4 weeks
Collards	0	95–100	10–14 days
Corn, sweet	0	95–98	5–8 days
Cucumbers	10–13	95	10–14 days
Eggplants	8–12	90–95	1 week
Endive and escarole	0	95–100	2–3 weeks
Garlic	0	65–70	6–7 months
Greens, leafy	0	95–100	10–14 days
Horseradish	–1.0–0	98–100	10–12 months
Kale	0	95–100	2–3 weeks
Kohlrabi	0	98–100	2–3 months
Leeks	0	95–100	3–6 months
Lettuce	0	98–100	2–3 weeks

Commodity	Temperature °C	Relative Humidity (%)	Approximate Storage Life
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TABLE 4–10.
Proven Disinfectants

Sanitizing Compound	Mixing Rate with Water
Hypochlorites (bleaches[1, 2] 5.25–6.0% active)	1 part to 9 parts water
Quaternary ammonium (10% active) e.g., DCD	1.0 mL per 300 mL water
Phenolic compounds[3] (sold as hospital disinfectants)	See label. Use rate listed for heavy spills.
37% formalin solution[2]	3 L per 100 L water

[1] Corrosive to metal surfaces.
[2] Wear a suitable respirator. Ventilate following treatment. Fumes are toxic to plants.
[3] Provides residual action.

Sanitizing reduces the pathogenic and spoilage micro-organisms. Cleaning must be done before sanitizing, otherwise the sanitizers will not be effective. Use clean rinse water after using sanitizers.

There are many products and procedures for sanitizing storages and equipment. See Table 4–10, *Proven Disinfectants*, left, for a short list of proven disinfectants.

For more information, consult these OMAFRA Factsheets:

- *Long-Term Storage of Carrots*
  Order No. 98-073
- *Storage of Cabbage*
  Order No. 90-055
- *Troubleshooting Cold Storage Problems*
  Order No. 94-083
- *Sizing and Laying Out a Short-Term (Summer) Refrigerated Storage for Fruits and Vegetables*
  Order No. 92-124
- *Humidity in Refrigerated Storages for Fruits and Vegetables*
  Order No. 88-055
- *Chilling Injury of Horticultural Crops*
  Order No. 98-021
- *Tunnel Forced-Air Cooler for Fresh Fruits and Vegetables*
  Order No. 98-031

5. Crop Management Recommendations

ASPARAGUS

Cultivars

Consult plant suppliers for description of varieties and availability of plants 1 year in advance of planting. Consult the Ontario Asparagus Grower's Marketing Board for seed availability.

All-Male Hybrids

Guelph Millennium

This hybrid produced marketable yields higher than Jersey Giant in experiment station trials. It is more susceptible to rust and requires more intensive disease management than Jersey Giant.

Jersey Giant

Jersey Giant produces good, marketable yields and has good rust tolerance.

Jersey Knight

Jersey Knight produces good, marketable yields and has good rust tolerance.

Growing Seedlings

Soak seed in water about 32°C for 3–4 days. Dry and sow immediately in early spring in fertile, well-prepared soil. Plant seed 2.5–4 cm deep and 8–10 cm apart in rows 45–60 cm apart. One kilogram of good seed should provide enough crowns to plant 1 hectare. To allow for selection of strong plants, plan to grow more plants than is needed. Date of seeding is about mid-May or once the ground is prepared and warm enough for seeding. Sow 11 kg of seed/ha (approximately 250,000 crowns/ha). Keep weeds and grasses controlled at all times.

Field Selection and Preparation

Asparagus is a long-term vegetable crop that should produce viable yields for 15 or more years. Therefore, thorough planning is essential for success. Field selection and preparation are key to good long-term production. Plant only into well-drained sandy or sandy loam soil free of perennial weeds and grasses. Eradication of perennial weeds and supplemental drainage improvement must be completed before the year of transplanting.

Soil testing is highly recommended to determine fertility levels and pH before transplanting.

Ideal soil pH should range between 6.0 and 6.8.

If possible, seed a green-manure crop the year before transplanting to increase soil organic matter. Livestock manure can also be used.

Transplanting and Spacing

In early spring, dig the 1-year-old plants, discard the weak or small crowns (less than 20 g). Up to one-third of the total crowns may be discarded. Plant the others in furrows so that the tops of the crowns are 15 cm deep. Space the plants 22–30 cm apart in rows 1.2–1.5 m apart. Using a furrow opener, set crowns at the desired depth (15 cm) and cover immediately, level with the surrounding soil surface and firm with packing wheels. Control weeds to retain high plant populations and vigorous growth.

Tillage and Fern Disposal

Clip asparagus fern at 15–20 cm high in the fall to allow stubble to catch drifting snow for better crown protection. The stubble can be cut up with a rotary or flail-type mower before minimum and light disking in early spring. The fern contributes organic matter to the soil. Use minimum cultivation for fern disposal and weed control. Excessive and deep tillage can injure crowns, which can increase *Fusarium* infection and reduce yields. Use zero tillage where suitable.

Harvest of Spears

Most asparagus plantings are vigorous enough that they can be harvested for about 10–14 days in the spring of the third year after field setting (for example, if the field is set in the spring of 2000, the first limited harvest would be in the spring of 2002). If asparagus vigour has been reduced

by weed competition, insects, disease or any other stress factor, harvest should be delayed until the third year after field setting. A 4-week harvest can then be undertaken.

An established asparagus planting is usually harvested for approximately 6 weeks. Harvesting should be terminated sooner if the emerging spears are too thin to meet the grade standards.

An average harvest should be in the range of about 100 kg/ha per picking. With an average of 30 harvest days/season (for fully mature plantings), economic yields should be about 3,000 kg/ha.

Fertilizer

Nitrogen

For asparagus seeded in a nursery, apply up to 75 kg N/ha. For new plantings of crowns and established plantings, apply up to 110 kg N/ha.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 3–5, Table 3–6 and Table 3–7 on page 24 and page 25.) Take the soil sample at the depth of planting.

Application

For the nursery, broadcast the nitrogen with the phosphate and potash required and work in before seeding. An additional 50 kg N/ha may be applied as a side-dress application in August or early September if rainfall is excessive. For new plantings, broadcast the nitrogen with the potash preplanting. The phosphate should be banded below the crowns at planting. If a green-manure crop is planted in the previous year, apply 30–40 kg N/ha and as much phosphate and potash as that crop requires, based on soil tests, before or at seeding. If manure is applied or legume sod is plowed down, reduce the nitrogen application. (See Table 3–10 on page 28 and Table 3–11 on page 29.) For established plantings, broadcast half the nitrogen with all of the phosphate and potash required in early spring. Broadcast the remainder of the nitrogen immediately after harvest.

Fall Seeding of Rye

The fall seeding of rye can be done in late August to mid-September. Approximately 4 bu/ha can be broadcast (for example, using a Vicon spreader). The rye can be "burned" down with a herbicide in the spring after mowing the fern and before fertilizer is applied. The rye will serve to reduce sandblasting. This practice is suited to no-till situations and will minimize weed seed germination as soil will not be disturbed. The ground may remain cooler initially, resulting in a slightly later harvest date.

Crop Rotation

When given a choice, asparagus should not be planted into fields that have previously grown asparagus. Perhaps the greatest cause of declining yields over time is due to "asparagus decline," a "complex" involving *Fusarium* diseases. Two species of *Fusarium* are of particular concern.

1) *Fusarium oxysporum* is found in all soils, all the time, so its presence cannot be avoided. However, the concentration or level of this disease will increase in soils where asparagus plants become infected. Once an asparagus field has been taken out of production, it usually takes about 5 years for the disease level to decrease to its "normal" or base concentration.

2) *Fusarium moniliforme* is a soil-borne disease that can be hosted by both asparagus and corn. Where corn has become infected with this disease, the concentrations of the fungus will also increase. Therefore, it is recommended that asparagus not be planted in a field within 3 years of corn.

Disease Management

Consult the OMAFRA Factsheet, *Diseases of Asparagus*, Order No. 82-045.

Rust

All commercial cultivars are susceptible to rust. Disease control is achieved only with thorough spray coverage on a regular preventive schedule. This spray must protect new foliage as it grows, before rust spores can land on it and germinate. Start spraying new, non-harvested plantings as soon as growth is about 30 cm high (late May). For harvested plantings, begin spraying as soon as fern growth commences after harvest is complete. A 7- to 10-day schedule is essential until at least late August to protect the fern growth. A high-boy sprayer with drop arms and 3 nozzles/row is needed for full spray coverage. Spray with one of the fungicides as described in Table 5–1, *Rust Control Recommendations for Asparagus*, below.

TABLE 5–1.
Rust Control Recommendations for Asparagus

Common Name	Group	Trade Name	Rate per Hectare
zineb	dithiocarbamate	Zineb 80 WP	2.5–2.75 kg
metiram[1]	dithiocarbamate	Polyram 80 DF	2.25–3.25 kg
myclobutanil	triazole	Nova 40 W	340 g in 370 L water/ha

[1] Use high rate on full-grown fern.

M121

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Botrytis

This disease attacks plants that are damaged from rust or beetle feeding. Under wet weather conditions, it can cause serious plant injury. A regular spray program for rust and good control of beetles before extensive feeding occurs is the best control recommendation.

Fusarium Diseases

Avoid replanting on land that previously grew asparagus. Otherwise, fumigate soil with Vorlex 0.6 L/10 m^2 before planting. Consult the manufacturer's directions. Follow all safety precautions.

Use treated seed when establishing seed beds. Use vigorous 1-year-old crowns when transplanting.

Care should be taken to avoid stresses as these make asparagus more susceptible to *Fusarium* diseases and reduce the longevity of the planting.

Stresses that promote *Fusarium* diseases include over-picking, picking before crowns are well established, insect and other disease damage, weed competition, excessive deep tillage, poor soil drainage, soil compaction, acidic soil pH, drought, injury from misapplication of pesticides, fertilizers, manure and low fertility.

Purple Spot (Stemphylium)

This fungal disease results in purple spots, often only on the windward side of the spear. Sandblasting will pit young asparagus spears allowing fungal spores a point of entry into the stem. This disease tends to be more prevalent during colder harvest seasons. It does not affect the internal tissue of the spear, but infected spears may be rejected from fresh-market sales. Purple spot can also infect fern growth during wet and humid weather causing mild to severe discoloration of mature plants.

There seems to be no effective chemical control for this disease. However, destroying infected fern and plant debris, which are sources of over-wintering spores, will help reduce the incidence of this disease.

Insect Management

Asparagus Beetles

Because there are several generations of these beetles, they are a constant threat throughout the season. Begin spraying when adult beetles are observed before egg laying in the spring.

If monitoring indicates a need, spray with one of the pesticides described in Table 5–2, *Insect Control Recommendations for Asparagus*, on page 52.

Bee Warning

Dimethoate is toxic to bees and should not be used during the bloom period. Carbaryl is especially toxic to bees and should not be used during the fern-growth period. With other insecticides, losses to bees can be reduced if sprays are applied in early morning or late evening when the bees are not foraging. Advise local beekeepers of spraying activity (see the section on *Bee Poisoning* on page 8).

Cutworms

Apply one of the pesticides described in Table 5–2 on page 52 when cutworm damage first becomes apparent. In addition, refer to Table 2–2, *Cutworm Treatments*, on page 16.

Aphids

Sprays should only be used during a non-producing season or as a post-harvest treatment and if monitoring indicates a problem. For immature asparagus, begin application mid-May. For mature asparagus, begin application July 1, after the crop has been harvested.

If monitoring indicates a need, spray with one of the pesticides recommended in Table 5–2 on page 52.

Tarnished Plant Bugs

If monitoring indicates a need, dimethoate, as recommended for aphids, will help control tarnished plant bug in asparagus (see Table 5–2).

Pigweed Casebearer

Control pigweed completely in the planting and in headlands as casebearers that develop on pigweed may contaminate the crop in May and early June the following year.

Mechanical Injury

Hooking

Bent spears are caused by some sort of injury to the spear, either above or below ground. Spears will "hook" into prevailing winds where sandblasting is a problem and into the injured side of the stem where damage has occurred from cutworm feeding, inadvertent nicks from cutting knives and abrasions from sharp stones, etc.

Nematode Control

Asparagus is not known to be a host for any species of nematodes, perhaps due to some alleopathic effect. Therefore, the ground does not need to be fumigated to control this pest. Crops sensitive to nematodes can enjoy

Botrytis

This disease attacks plants that are damaged from rust or beetle feeding. Under wet weather conditions, it can cause serious plant injury. A regular spray program for rust and good control of beetles before extensive feeding occurs is the best control recommendation.

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Nematode Control

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TABLE 5–2.
Insect Control Recommendations for Asparagus

Common Name	Group	Trade Name	Rate	Days to Harvest
Aphid				
pirimicarb	carbamate	Pirimor 50 DF	1 kg in 675 L of water/ha	**Immature asparagus** Begin application mid-May. **Mature asparagus** Begin application July 1, after crop has been harvested.
dimethoate	organophosphate	Cygon 480 E	2.3 L in 675 L of water/ha	
		Lagon 480 E	2.3 L in 675 L of water/ha	
Asparagus Beetle				
deltamethrin	pyrethroid	Decis 5 EC	200 mL/ha	Post-harvest use only
cypermethrin	pyrethroid	Cymbush 250 EC	140 mL/ha	1 day
carbaryl[1,2]	carbamate	Sevin XLR Li	2.5–6.4 L/ha	2 days
methoxychlor	diphenylethane	Methoxychlor 50 W	1.7–4.3 kg/ha	3 days
malathion	organophosphate	Malathion 500 EC	2.5 L/ha	1 day
		Malathion 25 WP	5.5 kg/ha	1 day
rotenone	botanical	Rotenone 5% WP	6 kg/ha plus spreader	1 day
Cutworm				
carbaryl[2]	carbamate	Sevin XLR Li	2.5–6.4 L /ha	2 days
permethrin	pyrethroid	Pounce 384 EC	180 mL /ha	2 days

[1] Use only during harvest, not during fern growth period.
[2] See box on *Bee Warning* on page 51.

a relatively safe period when planted after asparagus plantings have been removed.

Physiological Disorders

Hollow Stem

This problem tends to be more prevalent in young spears during periods of warm, wet weather resulting in very rapid spear growth. Seasons with moderate temperatures and even growth will result in a low incidence of hollow stems. Although this problem does not really affect the eating quality of the spear, some may find its appearance objectionable.

Storage of Spears

Freshly harvested asparagus is very perishable and loses quality rapidly. Collect the spears as soon as possible, protect them from the sun and move them to cold storage, the processor or a market as soon as possible. If short-term storage is necessary, store under high humidity at 1°C–2°C. Hydrocooling is the most effective and rapid way of removing field heat from asparagus spears.

Visit the vegetable page on the OMAFRA Web site at http://www.gov.on.ca/OMAFRA/english/crops/hort/vegetable.html

BEAN

Cultivars

Varieties listed are suggestions for Ontario from seed companies, growers, researchers and extension personnel. In some cases, other varieties may be suitable for your area or market. Growers are encouraged to conduct their own field trials to evaluate varieties under Ontario growing conditions. Because varieties of crops change frequently; check with a range of seed company representatives for additional recommendations and variety descriptions.

Processing

Follow processors' recommendations

Fresh Market

Table 5–3, *Bean Cultivars,* below, outlines fresh-market cultivars recommended for growing in Ontario.

TABLE 5–3.
Bean Cultivars

Cultivar	Relative Maturity[1]	Comments
Green Beans		
Rhapsody	51	Straight, smooth, round, attractive pod
Storm	51	High yield potential, good cold soil emergence
Hialeah	53	Erect plant, high pod set, long pod
Stallion	54	High yield potential, excellent pod quality
Strike	55	Consistent, high yield, medium-light green, tolerant to CBMV
Bronco	55	Darker green pod, late season, very long pod
Shade	56	Medium green, slender, attractive pod
Prosperity	58	
Wax (Yellow) Beans		
Rocdor	53	Long, straight pods, tolerant to CBMV
Gold Rush	55	Mid-season, bright yellow pod
Gold Mine	55	Good disease resistance
Nugget	56	High yield potential, light pod colour, heavy pod
Eureka	57	Late, very high yield
Lima Beans		
Early Thorogreen		
Fordhook 242		
Mendoza Bush		
Specialty Beans		
French Horticultural		
French Filet		
Romano		

[1] Days from emergence.
Days to maturity will depend on weather and planting conditions.

TABLE 5–4.
Spacing and Seeding Rates for Snap Beans

Row Spacing (cm)	Plants per Metre of Row	Harvest Method
75 to 90	20 to 24	Hand harvest or mechanical
50 to 60	16 to 22	Mechanical

Spacing and Seeding

Lima Beans

Use 55–65 kg of seed /ha. Seed approximately 4–5 cm deep depending on soil moisture. Rows are spaced 60–70 cm.

Snap Beans — Green and Yellow (Wax)

Sow as shallow as soil moisture permits, usually 2.5–4 cm deep. Planting should begin only after soil temperature has reached 15°C. At lower temperatures, seed decay may reduce stand.

The row spacings and seed rates in Table 5–4, *Spacing and Seeding Rates for Snap Beans,* above, are suggested for optimum yields depending on the harvest method. Because seed size varies greatly between cultivars, the seeding rate must be adjusted by seed count. Seeding rates must also be adjusted according to germination percentage and soil temperature at planting. Increase seeding rate slightly if seeding in cool soils to compensate for reduced stands. **Note:** Dark-coloured seeds have better cold soil emergence.

Fertilizer

Nitrogen

Apply 30–40 kg N/ha prior to planting. This may be applied as a pre-plant broadcast application or banded through the planter, 5 cm below and 5 cm to the side of the seed. Side-dressing of nitrogen is only recommended following heavy rains if foliage shows nitrogen deficiency. Avoid over-application of nitrogen as this reduces concentration of maturity and causes excess plant growth.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 3–5, Table 3–6 and Table 3–7 on page 24 and page 25 for phosphorus and potassium requirements).

Application

Fertilizer may be broadcast before seeding and worked in or banded 5 cm below and 5 cm to the side of the seed. Because high rates of banded potassium can reduce yield, banded potassium should not exceed 60 kg K_2O/ha.

TABLE 5–5.
Disease Control Recommendations for Beans

Common Name	Group	Trade Name	Rate per hectare	Days to Harvest	Notes
Bacterial blight					
copper hydroxide	inorganic	Champion 50 WP	2.25–3.25 kg	1	
		Kocide 101 WP	2.25–3.25 kg	1	
***Botrytis* gray mould, *Sclerotinia* white mould**[1]					
benomyl	benzimadazole	Benlate 50 WP	2.25 kg	14	Spray at first bloom.
dichloran	quinone	Botran 75 W	3.25 kg	2	Spray at first bloom.
iprodione	dicarboximide	Rovral WP	1.5 kg	15	Spray at 50% bloom.
vinclozolin	dicarboximide	Ronilan DF	1.0–1.5 kg	14	Spray at first bloom.
***Pythium* damping-off, *Phytophthora* root rot**					
metalaxyl-M	acylamine	Ridomil Gold 480 EC	300 mL[2]		Snap beans only. Apply only once per year.

[1] For snap beans grown in fields recently affected by white mould.
[2] Based upon 2.3 mL per 100 m of row using a 20-cm spray band and a 76-cm row spacing.

Micronutrients

Boron

Beans are very sensitive to boron toxicity and should not be grown the year after boron has been applied to previous crops such as cole crops, celery or rutabaga.

Manganese

Manganese deficiency may be a problem on beans on some soils with pH values above 6.5. Correct the deficiency as soon as detected by spraying the foliage with 1.0 kg manganese/ha from manganese sulfate or from manganese in chelated form in 300 L of water. Use a spreader sticker in the spray. If the deficiency is severe, a second spray may be beneficial. Soil application is not recommended for manganese because of the large amounts required. Consult the section *Manganese* on page 27, and Table 3–8, *Application Rates for Magnesium, Calcium and Micronutrients,* on page 26.

Zinc

Zinc deficiency has been reported on beans in other areas, but appears to be very rare in Ontario.

Disease Management

- Plant seed that is free from organisms causing bacterial blight, anthracnose, common mosaic and yellow mosaic. The best source of snap bean seed free from anthracnose and blight is the Western U.S.
- Practice crop rotation of at least 3 years to help control *Fusarium* and other soil-borne root rots, bacterial blight, anthracnose and *Sclerotinia* white mould. Where disease is a problem, it may be necessary to practice a 4- to 5-year rotation. Include crops other than field beans, snap beans, pole beans, kidney beans, lima beans, soybeans and peas in the rotation.
- Maintain vigorous plant growth. Fertilize adequately. Avoid poorly drained or compacted soils.
- Do not cultivate or harvest when plants are wet.
- Plow under crop residues in the fall to hasten destruction of disease organisms. Do not spread bean refuse or manure containing bean refuse on land intended for beans during the next 3 years.

Bacterial Blight

Table 5–5, *Disease Control Recommendations for Beans,* above, shows protectants that help manage bacterial blight.

Common Mosaic (CBMV) and Yellow Mosaic

Common mosaic virus is seed-borne or spread by aphids from infected beans. Some of the recommended snap beans are resistant to this virus. Check with your seed supplier. Avoid planting beans next to forage legumes or sweet clover from which aphids may spread yellow mosaic.

Pythium Damping-Off & Phytophthora Root Rot

For damping-off, see the section *Damping-Off of Seedlings* on page 12. Practice regular crop rotation and ensure good drainage in the field. In infested areas, apply fungicide as outlined in Table 5–5, above.

Sclerotinia White Mould, Botrytis Gray Mould

Plant fields in exposed areas where air circulation is maximum. Treat snap beans grown in fields where white mould and gray mould have been a problem in recent years as described in Table 5–5, above.

All sprays must penetrate the crop canopy and contact blossom petals. Use of drop nozzles, overhead nozzles and high pressure (up to 2,000 kPa) give best results. Applications made after bloom are not effective. If wet weather persists, a second spray will be beneficial.

Alternaria Pod Spot

Alternaria pod spot causes rust-coloured flecks on mature pods. Yellow wax beans and some varieties of green beans

TABLE 5–6.
Insect Control Recommendations for Beans

Common Name	Group	Trade Name	Rate per hectare	Days to Harvest	Notes
Aphid					
dimethoate	organophosphate	Cygon 480 E	0.7–1.0 L	7	Lima beans only.
		Lagon 480 E	0.7–1 L	7	Snap beans only.
malathion	organophosphate	Malathion 25 WP	2.75–5.5 kg	1	
naled	organophosphate	Dibrom EC	1.1–2.2 L	4	Lima beans only.
Corn borer					
permethrin	pyrethroid	Pounce 384 EC	260 mL	7	
methomyl	carbamate	Lannate SP	550g	7	Minimum period for re-entry is 24 hours.
carbaryl	carbamate	Sevin XLR Li	5.25 L	5	
Green cloverworm, Leafhoppers, Mexican bean beetle					
carbaryl	carbamate	Sevin XLR Li	1.25–2.5 L	5	
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	1.5–2.5 L	2	
		Thionex 400 EC	1.5–2.5 L	2	Leafhopper & Mexican bean beetle only.
dimethoate[1]	organophosphate	Cygon 480E	0.7–1.0 L	7	Leafhopper & Mexican bean beetle only.
		Lagon 480E	0.7–1.0 L	7	Leafhopper & Mexican bean beetle only.
malathion	organophosphate	Malathion 25 WP	2.75–5.5 kg	1	Mexican bean beetle only.
		Malathion 500 EC	1.8 L	3	Mexican bean beetle only.
Spider mite					
dicofol	diphenylethane	Kelthane 50 W	1.0–1.25 kg	7	Apply only once/season.

[1] Do not graze or feed treated foliage to livestock.

such as Strike are very susceptible. Harvesting beans earlier can occasionally avoid severe losses.

Insect Management

Seed Maggots, Wireworms and Seed Decay

Treat seed with diazinon, lindane and a fungicide. (See the section *Chemical Seed Treatment* on page 11.)

Leafhoppers, Mexican Bean Beetle, Green Cloverworm, Aphids, and Spider Mite

If crop monitoring indicates, spray with a pesticide recommended in Table 5–6, *Insect Control Recommendations for Beans*, above.

Corn Borer

Corn borer has been a problem on snap beans in some areas in the past few years. Control requires regular and consistent monitoring and a number of carefully timed applications of insecticides. Consult your processing field person or a crop specialist and Table 5–6, above.

For more information, consult the OMAFRA Factsheet, *European Corn Borer in Sweet Corn and Other Horticultural Crops*, Order No. 97-019.

Tarnished Plant Bug

This pest may damage flowers and fruit leading to flower abortion and/or pin-point lesions on leaves. It is effectively controlled with dimethoate when sprayed for aphids or leafhoppers.

For more information, consult the OMAFRA Factsheet *Tarnished Plant Bug Damage on Vegetable Crops in Ontario*, Order No. 98-025.

Physiological Disorders

Bronzing

Bronzing is a physiological disorder caused by high levels of atmospheric ozone associated with air pollution. It occurs following the initiation of flowering and after the older leaves become fully mature. A bronze-coloured stipple develops on the pods and the upper surface of the leaves. Pod and seed set are usually reduced, and the plants age prematurely. Dry beans and limas appear more sensitive than snap beans, and cultivars within these types differ in susceptibility.

Visit the vegetable page on the OMAFRA Web site at http://www.gov.on.ca/OMAFRA/english/crops/hort/vegetable.html

BEET

Cultivars

The varieties listed in Table 5–7, *Beet Cultivars*, right, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. In some cases, other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under Ontario growing conditions. Varieties of crops change frequently; check with a range of seed company representatives for additional recommendations and variety descriptions.

TABLE 5–7.
Beet Cultivars

Some varieties may be suitable for bunching and non-bunching.

Suitable for Bunching	Suitable for Non-Bunching
Warrior	Pacemaker III
Greentop	Red Ace
Avenger	Ruby Queen
Detroit Dark Red	Kestrel
	Monet
	Scarlet Supreme
Processing	
As recommended by processors.	

Seed Treatment

Treat seed with thiram seed protectant before planting. Follow manufacturer's directions.

Field Seeding and Spacing

For a continuous supply of beets for bunching, sow seed at 2-week intervals, from early April to the end of July. For storage and processing, sow about 10 weeks before late-fall harvesting. Seed will not germinate at temperatures lower than 4°C. Optimum germination temperature is from 10°C to 29°C. Sow seed 1.2–2.0 cm deep. About 7 kg of seed will plant one hectare. Thin plants 5–8 cm apart. No thinning is required on muck soils when seeders are adjusted to ensure a stand of 32–40 plants per metre of row. Plant rows 30–40 cm apart, depending on foliage size of cultivar.

Fertilizer

Nitrogen

On mineral soils, apply up to 110 kg N/ha. On muck soils, apply up to 40 kg N/ha. If manure is applied or legume sod is plowed down, reduce the nitrogen application. (See Table 3–10 on page 28 and Table 3–11 on page 29.)

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 3–5, Table 3–6 and Table 3–7 on page 24 and page 25).

Application

On mineral soils, broadcast 65 kg N/ha and all of the phosphate and potash required before planting and work in. The remainder of the nitrogen should be side-dressed.

Micronutrients

Boron

Boron deficiency shows up as a breakdown and corky, dark discoloration of internal tissues. Consult the section *Boron* on page 27, and Table 3–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 26.

Manganese

Deficient plants show marked yellowing between the leaf veins; the veins themselves remain green. To correct a deficiency spray with manganese sulfate, consult the section *Manganese* on page 27, and Table 3–8 on page 26.

Disease Management

Damping-Off and Seedling Diseases

See the section on *Seed Treatment* on page 11.

Internal Breakdown (Boron Deficiency)

Most likely to occur on alkaline soils after prolonged hot, dry periods. (See the section on *Boron* on page 27.)

Cercospora Leaf Spot

This disease is more of a problem on fresh, bunched beets. If monitoring indicates a need, apply as indicated in Table 5–8, *Disease and Insect Control Recommendations for Beets*, on page 57.

Pocket Rot / Root Rot

This disease is caused by *Rhizoctonia* fungi. Symptoms vary from cankers on lower petioles and crowns to root rot of beets. Disease is more severe when long periods of wet conditions prevail. Avoid splashing soil onto beet roots and rotate with grain crops.

TABLE 5–8.
Disease and Insect Control Recommendations for Beets

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Cercospora Leaf Spot					
copper	inorganic	Copper 53 W	4 kg	1	
Aphid					
dimethoate	organophosphate	Cygon 480-E	0.75 L	3	
parathion	organophosphate	Parathion 960 E	225–375 mL	14	Minimum period for re-entry is 7 days.
diazinon[1]	organophosphate	Diazinon 50 WP	1.1 kg	14	
		Diazinon 500 EC	1.1 L	14	
		DZN 600 EW	0.915 L	14	
malathion[1]	organophosphate	Malathion 25 W	2.25–5.5 kg	7	
		Malathion 500 E	1.8–2.5 L	3	
Leaf Miner					
dimethoate	organophosphate	Cygon 480-E	0.7 L	3	
parathion	organophosphate	Parathion 960 E	225–375 mL	14	Minimum period for re-entry is 7 days.

[1] Control of aphids with diazinon and malathion has been inconsistent in many areas.

Insect Management

Leaf Miner

Leaf miner control is usually required only for bunching beets. When miners first appear, spray with one of the pesticides recommended in Table 5–8, *Disease and Insect Control Recommendations for Beets*, above.

Aphids

If monitoring indicates a problem, spray with one of the pesticides recommended in Table 5–8, above.

Webworms

Webworms are usually only a minor problem in Ontario. If the thresholds of 3–6% plants infested are exceeded, treatment may be warranted especially on fresh, bunched beets. Only parathion is labeled for webworms. Use as recommended in Table 5–8, above, for leafminer and aphids.

Cutworms

Cutworms are only a minor problem in Ontario. If monitoring indicates a problem, consult the section *Cutworms* on page 16 for cutworm management recommendations.

Nematode Control

To avoid damage from sugar-beet cyst nematode, do not plant beets following rhubarb, spinach or beets. (See the sections *Crop Rotation for Control of Diseases* on page 13 and *Nematodes* on page 17.)

Quality and Storage

Heavy rains following a hot, dry period or extended periods of high temperature will cause poor colour. Rains in the late summer or early fall, when cooler temperatures occur, may increase the intensity of colour. In general, cool temperatures produce the best flesh colour.

Mature topped beets may be stored for up to 5–6 months at 0°C and 90–95% relative humidity.

Visit the vegetable page on the OMAFRA Web site at
http://www.gov.on.ca/OMAFRA/english/crops/hort/vegetable.html

COLE CROPS:
BROCCOLI, BRUSSELS SPROUTS, CABBAGE, CAULIFLOWER, HORSERADISH, KALE, KOHLRABI

Cole-Crop Cultivars

The cole-crop varieties listed in Table 5–9, *Cole-Crop Cultivars*, right, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. In some cases, other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under Ontario growing conditions. Varieties of crops change frequently; check with a range of seed company representatives for additional recommendations and variety descriptions.

Seed Treatment

Sow seeds that have been hot-water-treated and dusted with thiram (dithiocarbamate group) or captan (phthalimide group) seed protectant. Follow the manufacturer's directions. Hot-water treatment (see the section *Hot-Water Treatment* on page 11) is most important to help prevent black rot, blackleg and bacterial leaf spot. To control black rot, seed may be treated with streptomycin (antibiotic group) as an alternative to hot-water treatment. Follow the manufacturer's directions on the label.

Seeding and Spacing

About 300–350 g of seed will provide enough transplants for 1 hectare at standard spacing. See Table 5–10, *Seeding and Spacing of Cole-Crop Vegetables*, on page 59, for recommendations. Note that the newer, compact hybrids may be grown at closer spacings than the older traditional cultivars.

With Brussels sprouts grown for once-over harvesting and especially where smaller sprouts are required for freezing, uniformity of the sprouts up the stem can be improved by growing the plants on a closer square spacing, e.g., 60 x 60 cm, or even as close as 53 x 53 cm.

For broccoli crops that will be harvested during the hot, humid weather of late August to early September, increase plant spacings to the wider end of the range recommended.

Stand Establishment

Direct seeding in the field is possible for late summer and fall crops of cabbage, cauliflower, broccoli and Brussels sprouts, however, this practice is not widely used in Ontario. This may be because seed of the newly developed hybrids is very expensive compared to the traditional, open-pollinated cultivars.

TABLE 5–9.
Cole-Crop Cultivars

CABBAGE		
Early	***Midseason***	
Balbro	Green Express YR	Megaton YR
Charmant	Bronco YR	Applause
Tucana	Superette	Hybrid 4
Farao	Ramada YR	Atlantis
Green Express YR	Rhinda	Fresco
Headstart	Prime Time	Balaton
Sun-up	Survivor (Questo)	Genesee (trial)
General YR	Loughton YR	Crown (trial)
	Multikeeper	Bobcat (trial)
	Cavalier	
Late (storage type)	***Red***	***Savoy***
Hinova YR	Primero	Famosa
Bingo	Rona	Melissa YR
Zerlina	Raven	Wirosa
Marathon	Red Jewel	Savoy Express
Saratoga YR	Super Red 77 YR	Primavoy
Loughton YR	Vitaro	
Missouri	Autoro (storage)	
Huron		
Amtrak YR		
Hilton		
CAULIFLOWER		
Early Crop	***Midseason***	***Late Crop***
Pathfinder	Amazing	White Sails
Minuteman	Wentworth	Rushmore
	Apex	Wentworth
	Fremont	Fremont
	Sierra Nevada	White Rock
		Minuteman
BROCCOLI		
Paragon	Premium Crop	Jaguar
Triathlon	Barbados	Regal
BRUSSELS SPROUTS		
Jade Cross E	Oliver	Vancouver
Harley	Diablo YR	Prince Marvel
HORSERADISH, KALE, KOHLRABI		
Refer to current seed catalogues for horseradish, kale or kohlrabi varieties suitable to your area.		

YR - *Fusarium* Yellows resistant (based on seed company claims and field trial testing)

Emphasis is now on once-over harvesting of some crops and reduced frequency of harvesting for others. This demands concentration of crop maturity. Serious consideration must be given to establishing transplants from plug trays as a prime method of promoting crop and maturity

TABLE 5–10.
Seeding and Spacing of Cole-Crop Vegetables

Vegetable	Distance Between Rows	Distance Between Plants
Cabbage (early), broccoli	60–75 cm	30–45 cm
Cabbage (late), cauliflower, Brussels sprouts	75–90 cm	45–60 cm
Horseradish	75–90 cm	40–60 cm
Kale	70–80 cm	thinned to about 30 cm apart
Kohlrabi	70–80 cm	thinned to about 10 cm apart

uniformity instead of from open-field seedbeds. Despite the higher initial cost of plug plants, considerable savings can be realized through higher recovery of plants per unit of seed, reduced costs of pulling plants and more rapid transplanting into the field. Plug-raised plants also establish more quickly and provide a more uniform and more vigorous population than bare-root transplants.

For direct seeding to be successful, soil management practices to reduce uneven plant stands and soil crusting are essential, although sometimes very difficult under Ontario conditions. Often, irrigation is required before seeding. Weed control can be more difficult in direct-seeding because of a lack of effective registered herbicides.

Fertilizer

Nitrogen

On mineral soils, broccoli, cauliflower and Brussels sprouts should receive 130 kg N/ha and cabbage 170 kg N/ha. Horseradish, kale and kohlrabi should receive about 110 kg N/ha. For muck soils, the suggested maximum is 130 kg N/ha with 70 kg N/ha preplant plus two sidedresses of 30 kg N/ha each, while cabbage should receive an initial 100 kg N/ha preplant. If manure is applied or legume sod is plowed down, reduce the nitrogen application. (See Table 3–10 and Table 3–11 on page 28 and page 29.)

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 3–5, Table 3–6 and Table 3–7 on page 24 and page 25.)

Application

Broadcast three-quarters of the nitrogen and all of the phosphate and potash required before planting, and work in. The remainder of the nitrogen should be side-dressed about 3 weeks after field setting. If rainfall is excessive, an additional 40 kg N/ha may be side-dressed on sandy soils. For muck soils, up to 70 kg N/ha should be applied before planting and the rest split into two equal side-dressings as needed.

Starter Solution

If no insecticide is being added to the planting water, use a starter solution high in nitrogen such as 20-20-20 at 1 kg/200 L and apply 0.2–0.3 L per plant. Under high-temperature conditions or in dry sandy soils, use only $^1/_2$ kg of 20-20-20/200 L of water. This will reduce the risk of crop injury under these growing conditions.

Micronutrients

Brown Heart or Hollow Stem (Boron Deficiency)

On soils known to be deficient in boron, apply 2.5–3.0 kg of boron/ha and disk-in before planting. Foliar sprays of boron can be made during the growing season. Boron deficiency has been shown to cause hollow stem in broccoli, but not all hollow stem is caused by boron deficiency. Consult the section *Boron* on page 27 and Table 3–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 26.

Whiptail (Molybdenum Deficiency)

This deficiency causes whiptail in cauliflower, broccoli, and Brussels sprouts. If molybdenum is deficient, apply sodium molybdate mixed with the fertilizer at rates supplying 0.6–0.8 kg of molybdenum/ha or apply 10–15 g of molybdenum per 100 L of water at 0.3 L per plant at transplanting. If deficiency symptoms appear in the field, spray immediately with 60 g of molybdenum dissolved in 300 L of water applied to 1 ha. Consult the section *Molybdenum* on page 28 and Table 3–8 on page 26.

Special Problems

Cabbage Splitting

Well-developed cabbage heads may split or burst if rain or a heavy irrigation follows a dry spell. Splitting results from rapid new growth due to the increased moisture. Splitting may be partially avoided by checking the plants' growth, for example, by breaking up some of the roots through deep cultivation. Proper irrigation may prevent splitting by helping to maintain steady plant growth.

Bolting

Premature seedstalk development may occur when plants are started too early and grown at temperatures that are too low, early in the growing season. The earlier the seed is sown, the greater the bolting tendency. Bolting may also be caused by extreme changes in temperature, poor soil conditions, low nutrient levels or other factors that cause checks to plant growth. Some cultivars, particularly early ones, are more susceptible to bolting than others.

Tipburn of Cauliflower and Cabbage

Tipburn can occasionally cause severe economic losses in cabbage and cauliflower. Tipburn is a breakdown of plant tissue near the centre of the head in cabbage and on the inner wrapper leaves of cauliflower. It is a physiological disorder associated with an inadequate supply of calcium in the affected leaf margins causing a collapse of the tissue and death of the cells.

High temperatures and fluctuating soil moisture conditions hinder the movement of calcium into the leaves, leading to tipburn. Calcium deficiency may also occur where soil calcium is low or where there is an imbalance of nutrients in the soil.

Secondary rot organisms such as *Erwinia sp.* can follow tipburn. In tied cauliflower, trapped moisture can move the disease organism onto the heads, resulting in discoloration and breakdown. Many varieties of cabbage and cauliflower have been noted to be free of tipburn problems. Consult the section *Calcium* on page 26 and Table 3–8, *Application Rates for Magnesium, Calcium and Micronutrients,* on page 26.

Cauliflower Buttoning

Buttoning is the premature formation of a cauliflower curd. Because the curd forms very early in the plant's life, the leaves are not large enough to nourish the curd to a marketable size. Buttoning usually occurs shortly after planting in the field, when normal plants of the same age are growing vegetatively. Losses are usually most severe in the early-planted crop during cold, wet seasons, when vegetative growth is reduced. Conditions that may cause buttoning include:

- a too-rapid hardening-off treatment of young plants raised under protection
- insufficient hardening-off treatment of young plants before being planted in the field
- unbalanced soil fertility in the field (particularly low nitrogen)
- low soil moisture
- extreme and continued cold weather (e.g., 4°C–10°C for 10 days or more) especially in combination with excess moisture
- certain diseases, insects and trace-element deficiencies, such as club root, root maggot and molybdenum deficiency (whiptail)

In short, conditions that reduce the vigour of the plant and retard vegetative growth appear to encourage buttoning. Some cultivars, particularly early ones, are more susceptible than others.

Cauliflower Blanching

A perfect head of cauliflower is essentially pure white or pale cream. Heads exposed to sunlight develop an objectionable yellow pigment. While the head is small it is covered by the small inner leaves that curve over it, but as the head grows and enlarges, these leaves begin to lift, and some other means of covering is necessary to exclude sunlight. The usual method is to tie the outer leaves over the heads when the heads are 8–10 cm in diameter.

Heads tied at different times should be marked by different colours of twine or rubber bands to indicate probable maturity date and make harvesting easier. In hot weather, blanching may take only 3–4 days, but in cool weather, when growth is slow, 8–12 days or more may be required.

Some cultivars are better able than others to give natural curd protection by the inner wrapper leaves, without tying. Generally speaking, the cultivars listed in Table 5–9, *Cole-Crop Cultivars,* on page 58, that originated in Europe have better natural curd protection than the traditional North American cultivars.

Broccoli Harvesting

Terminal broccoli heads are cut with 15–20 cm of stem. Lateral shoots from the axils of the leaves develop into marketable heads soon after the terminal head is removed. These laterals produce a continuous crop for several weeks. However, some of the new hybrids produce very few laterals. Continuity of production with these cultivars may be obtained by successive plantings in the spring and summer. Heads should be cut when the clusters are green and compact. Open and yellow clusters are undesirable.

Brussels Sprouts Harvesting

Harvesting should begin when the sprouts are firm and well formed. When picking, break off the leaf below the sprout and remove the sprout. The upper sprouts continue to form and enlarge as the lower ones are harvested. In an early crop, the lower sprouts should be picked as soon as they mature; otherwise, they will open up, become soft, turn yellow and eventually rot.

For a once-over harvest, top the plants, i.e., remove the growing point to prevent any further extension of growth and encourage the maturity of the small sprouts at the top of the stem. Topping is normally done when the sprouts at the bottom of the stem are about 12–20 mm in diameter. In this way, a full stem of uniform, marketable-sized sprouts will develop about 4 weeks later. Deleafing is necessary before a once-over harvest, but it should not precede harvesting by more than a day; otherwise, yield will be adversely affected.

TABLE 5–11.
Cole-Crop Disease Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Downy Mildew, Black Leaf Spot					
zineb	dithiocarbamate	Zineb 80 WP	2.25–3.25 kg	7	Not on horseradish, kale or kohlrabi.
copper sulphate[1]	inorganic	Copper 53 W	4.0 kg	1	Not on horseradish, kale or kohlrabi.
chlorothalanil	chloronitrile	Bravo 500F	2.5–4.8 L	7	Not on horseradish, kale or kohlrabi.
Black Leaf Spot only					
iprodione	dicarboximide	Rovral WP	3 kg	7	Storage cabbage.
				5	Cauliflower.

[1] Fixed copper may be phytotoxic to cauliflower.

Disease Management

Seed Decay, Damping-Off, Wirestem, Black Rot, Blackleg, Soft Rot, Bacterial Leaf Spot of Cauliflower

Sow seed that has been hot-water treated and dusted with thiram (dithiocarbamate group) or captan (phthalimide group). Hot-water treatment (see the section *Hot-Water Treatment* on page 11) is most important to help prevent black rot, blackleg and bacterial leaf spot. For the control of black rot, as an alternative to hot-water treatment, treat the seed with streptomycin (antibiotic group).

Caution: Streptomycin may be toxic to some cultivars. Follow the manufacturers' directions.

Note: Some cultivars are more susceptible to black rot than others. Check the seed packet to be sure that the incidence of black rot is not greater than 1 in 30,000 and check with seed company representatives about black-rot-tolerant cultivars.

Field seedbeds should not be located downhill from where cabbage and related crops have been grown or where residues of these crops will be blown by wind or spilled from passing trucks, etc. To control disease-causing fungi and nematodes in seedbed soil, steam the soil or fumigate it with Vapam or Vorlex according to the manufacturer's directions.

Where possible, follow a 3-year rotation with unrelated crops whether the crop is transplanted or direct-seeded. Avoid working among plants when they are wet. Do not irrigate with overhead sprinklers. In the fall or early spring, break up the crop refuse thoroughly and incorporate it into the soil. Consult the OMAFRA Factsheet, *Bacterial Diseases of Cruciferous Crops*, Order No. 86-046.

Fusarium Yellows/Wilt

Use resistant cultivars (consult seed catalogues). If susceptible cultivars are grown, produce transplants in steamed or fumigated soil, and transplant to fields where yellows has not previously appeared.

Clubroot

This fungus causes swollen roots and wilting plants (Consult the OMAFRA Factsheet, *Fungal Diseases of Cruciferous Crops*, Order No. 85-043). The resting spores in the fungus persist in soil for at least 7years. The organism is carried within and between fields in moving water. Therefore, avoid wet, poorly drained soils. Grow seedlings or transplants in soil free of disease. The most reliable control measure is liming with finely ground lime to a pH of 7.2. (Consult the OMAFRA Factsheet, *Soil Acidity and Liming*, Order No. 91-086.) Calcitic lime is preferable to dolomitic lime to attain a high level of soluble calcium (unless soils are low in magnesium). Where soil pH is above 7.0, gypsum is a more soluble source of calcium.

Do not use hydrated lime on seedbeds. Fumigate seedbeds with Vorlex or Vapam if disease-free beds are not available (consult the manufacturer's directions). Some field control is possible by using quintozene (chlorophenyl group) (PCNB 75) in the transplant water at the rate of 1.5 kg in 200 L, applying at least 0.2 L/plant (3,650–5,600 L/ha). Provide good agitation during application. Do not use quintozene emulsion. No other method of applying quintozene is recommended. Chemical control of clubroot is inconsistent.

Downy Mildew

Downy mildew may appear in the seedbed or late in the season. It spreads rapidly in cool, wet weather, and preventive spraying is recommended. The fungicides listed in Table 5–11, *Cole-Crop Disease Control Recommendations*, above, will only prevent new infections and not eradicate established lesions.

Black Leaf Spot (Alternaria)

This disease may be damaging in warm, wet seasons. Spray with one of the materials listed in Table 5–11 on page 61.

Note: It is important to control downy mildew and black leaf spot on storage cabbage. Rotate between chlorothalanil and iprodione. Apply iprodione on storage cabbage 7–14 days prior to harvest and on cauliflower 1–2 days prior to tying.

Insect Management

Caution

- **Do not use emulsifiable formulations in the planting water.**
- **Do not add fertilizer to planting water containing an insecticide unless recommended by the manufacturer or until experience has proven the mixture to be safe.**

Root Maggots

Root maggot management is primarily preventative, however, high soil temperatures, low soil moisture, natural predators, crop rotation and field sanitation are also important. Later plantings are less likely to require protection. See Table 5–12, *Root Maggot, Flea Beetle, Thrips and Slugs Control Recommendations for Cole Crops*, on page 63.

Flea Beetles

Monitoring greatly improves management. Up to the 6th-leaf stage, the tolerance for flea beetles is 1 per plant. After the 6th-leaf stage, flea beetles are less of a concern unless you are selling the tops of radishes or Asian cruciferous greens. Chinese/Indian mustard (*Brassica juncea* var. *crispifolia*) can act as an effective trap crop also. See Table 5–12 on page 63.

Cabbageworm, Cabbage Looper, Diamondback Moth Caterpillar

Infestations of cabbageworm and diamondback moth caterpillar may begin early in the season, whereas cabbage loopers usually appear after mid-July. Because the recommended insecticides are less effective against large larvae, check carefully for young larvae beginning soon after planting. Begin application of insecticides when young larvae are found and continue at 5- to 10-day intervals, or as necessary for adequate protection of the crop. Scouting is an excellent way to assess the population of cole-crop caterpillars and will make better use of available pest control products.

Table 5–13, *Cabbageworm, Cabbage Looper, Diamondback Moth Caterpillar Control Recommendations for Cole Crops*, on page 64, lists recommended pest control products by group. To limit the development of resistance, insecticides from one of the groups listed must be used alternately with one from another group. Use insecticides in the pyrethroid group during the fall as they are more effective than the others under cool conditions. Consult the OMAFRA Factsheet, *Caterpillar Pests of Cruciferous Crops*, Order No. 99-035.

Note: Many of these insecticides are not consistently effective against cabbage looper and diamondback moth larvae. The carbamates, azinphos-methyl and naled have been inconsistent in some areas. Spray small areas first to check if the product is working in your area. Also note the repeated use of synthetic pyrethroids in cole crop fields may lead to aphid resurgence.

Aphids

Good coverage (bottom of leaves) is essential for aphid control. Drop nozzles and increased water volumes are necessary. If monitoring indicates a need, spray with one of the pest control products listed in Table 5–14, *Aphid Control Recommendations for Cole Crops*, on page 65.

Thrips

Cabbage susceptibility to thrips injury varies with varieties grown and, in some cases, cultural practices in and around the field. Evidence also suggests that late plantings suffer less damage than earlier ones. Spraying for thrips should start once cupping of cabbage occurs. Thrips can also damage the curds of cauliflower leaving them unmarketable. Cypermethrin (pyrethroid group) and parathion (organophosphate group) are labeled for thrips control on cole crops. Rotation of these materials is necessary to reduce the potential for resistance. Also note that cypermethrin will not work well if used when temperatures are above 27°C.

Some varieties of cabbage are more susceptible to thrips and these may benefit the most from sprays. Ratings on thrip damage are obtained each year through storage cabbage variety trials. Over-mature cabbage is a prime target for thrips. Harvesting cabbage at the proper maturity will help reduce thrip loss. For an update on thrip ratings for cabbage, consult a crop specialist or seed company representatives.

If monitoring indicates a need, spray with one of the pest control products listed in Table 5–12 on page 63.

Consult the OMAFRA Factsheet, *Thrips on Onions and Cabbage*, Order No. 99-027.

TABLE 5–12.
Root Maggot, Flea Beetle, Thrips and Slugs Control Recommendations for Cole Crops

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Root Maggots					
Planting-Water Treatment					
azinphos-methyl	organophosphate	APM 50 W	1 kg in 1,000 L of water		Apply 115–170 mL/plant in transplant water. For cabbage, cauliflower, broccoli, Brussels sprouts only. Repeat in 2–3 weeks. Minimum period for re-entry is 48 hours.
		Guthion Solupak 50 WP			
		Sniper 50W			
		Guthion 240 SC	2 L/1,000 L of water		
chlorpyrifos	organophosphate	Lorsban 50 W	65 g/200 L of water Apply 200 mL/plant.	32	For cabbage only. Do not use starter fertilizers or lindane with Lorsban 50 W or Pyrifos 50 W.
		Pyrifos 50 W			
Treatment After Planting					
azinphos-methyl	organophosphate	APM 50 W	1 kg in 1,000 L of water. Apply 115–170 mL/plant.		For cabbage, cauliflower, broccoli, Brussels sprouts only. Repeat in 2–3 weeks. Minimum period for re-entry is 48 hours.
		Guthion Solupak 50 WP			
		Sniper 50W			
		Guthion 240 SC	2 L/1,000 L of water		
chlorpyrifos	organophosphate	Lorsban 4E	210 mL/130 L of water per 1,000 metres of row at 1,000 L of water/ha	32	For cabbage, cauliflower, broccoli, Brussels sprouts only. Apply in a 10-cm band on each side of the plant 3 days after transplanting.
		Pyrinex 480 EC			
Direct-Seeded Crops					
chlorpyrifos	organophosphate	Lorsban 4E	210 mL/130 L of water in at least 1,000 L of water/ha per 1,000 m of row	32	For cabbage, cauliflower, broccoli only. Apply 10 cm on each side of the plant 7–10 days after seeding or 3 days after transplanting.
		Pyrinex 480 EC			
		Lorsban 15 G	0.6–1.0 kg/1,000 m row		For cabbage, cauliflower, broccoli, Brussels sprouts only.
		Pyrifos 15 G			
Flea Beetles					
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	1.5–2.0 L	7	Not on horseradish, kale, kohlrabi.
		Thionex 400 EC	1.5–2.0 L	7	Not on horseradish, kale, kohlrabi.
carbaryl	carbamate	Sevin XLR Li	1.25–2.5 L	3	For cabbage and cauliflower.
				5	For broccoli, kohlrabi and Brussels sprouts.
				7	For horseradish.
				21	For kale.
cypermethrin	pyrethroid	Ripcord 400 EC	87.5–125 mL	3	Not on horseradish, kale, kohlrabi.
deltamethrin	pyrethroid	Decis 5.0 EC	150–200 mL	3	Use on cabbage only.
cyhalothrin-lambda	pyrethroid	Matador 120 EC	142 mL	1	For cabbage. Minimum period for re-entry is 24 hours.
				3	For broccoli, cauliflower, Brussels sprouts. Minimum period for re-entry is 24 hours.
permethrin	pyrethroid	Pounce 384 EC	90–180 mL	2	For horseradish.
				3	For cabbage, cauliflower, Brussels sprouts.
				7	For broccoli.
Thrips					
cypermethrin	pyrethroid	Ripcord 400 EC	87.5–125 mL	3	For cabbage, cauliflower, broccoli, Brussels sprout only.
		Cymbush 250 EC	200 mL	3	For cabbage, cauliflower, broccoli, Brussels sprout only. Use Agral 90 at 300 mL/1,000 L spray.
parathion	organophosphate	Parathion 960 E	375–590 mL	14	Not on kohlrabi, horseradish.
Slugs					
methomyl	carbamate	Lannate SP	775g	30	For Brussels sprouts only, and only by ground application. Minimum period for re-entry is 24 hours.

M121

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TABLE 5–13.
Cabbageworm, Cabbage Looper, Diamondback Moth Caterpillar Control Recommendations for Cole Crops

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Bacillus thuringiensis	microbial	Dipel 2XDF	55–550 g	0	275–550 g for loopers.
		Thuricide HPC	2.0–4.25 L	0	Use higher rates for looper control, heavy infestations or when foliage is dense.
permethrin	pyrethroid	Pounce 384 EC	90–180 mL	3	Cabbage, cauliflower, Brussels sprouts.
				7	Broccoli.
fenvalerate	pyrethroid	Belmark 300 EC	150–325 mL	14	Cabbage, cauliflower, Brussels sprouts. Do not use on broccoli, kale, kohlrabi, horseradish.
deltamethrin	pyrethroid	Decis 5.0 EC	150–200 mL	3	Not on kohlrabi, horseradish.
cypermethrin	pyrethroid	Ripcord 400 EC	87 5–125 mL	3	Cabbage, cauliflower, broccoli, Brussels sprout only.
	pyrethroid	Cymbush 250 EC	140 mL	3	Cabbage, cauliflower, broccoli, Brussels sprout only.
cyhalothrin-lambda[1]	pyrethroid	Matador 120 EC	142 mL	1	Imported cabbageworm and diamondback moth larvae on cabbage.
				3	Imported cabbageworm and diamondback moth larvae on broccoli, cauliflower, Brussels sprouts.
			83 mL	1	Cabbage looper on cabbage.
				3	Cabbage looper on broccoli, cauliflower, Brussels sprouts.
methomyl[1]	carbamate	Lannate SP	270–540 g	1	Cabbage.
				7	Cauliflower, broccoli, Brussels sprouts.
carbaryl	carbamate	Sevin XLR Li	2.5–5.25 L	3	Cabbage and cauliflower.
				5	For broccoli and Brussels sprouts.
				7	For horseradish.
				21	Kale.
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	1.5–2.0 L	7	Not on kale, kohlrabi, horseradish.
		Thionex 400 EC	1.5–2.0 L	7	Not on kale, kohlrabi, horseradish.
naled	organophosphate	Dibrom EC	1.1–2.2 L	4	2.2 L rate for loopers only. Not on kohlrabi, horseradish.
methamidophos[2]	organophosphate	Monitor 480 LC	1.1–2.25 L	7	For cabbage, cauliflower.
				14	Broccoli, Brussels sprouts.
azinphos-methyl[2]	organophosphate	Guthion Solupak 50 WP	1.12–1.75 kg	7	Brussels sprouts. Maximum 3 applications per season.
				15	Broccoli and cauliflower. Maximum 3 applications per season.
				21	Cabbage. Maximum 3 applications per season.
		Guthion 240 SC	2.25–3.5 L	7	Brussels sprouts. Maximum 3 applications per season.
				15	Broccoli and cauliflower. Maximum 3 applications per season.
				21	Cabbage. Maximum 3 applications per season.
		Sniper 240 E	2.25–3.5 L	7	Brussels sprouts. Maximum 3 applications per season.
				15	Broccoli, cauliflower. Maximum 3 applications per season.
				21	Cabbage. Maximum 3 applications per season.
		Sniper 50 W Clean Pak	1.12–1.75 kg	7	Brussels sprouts. Maximum 3 applications per season.
				15	Broccoli & cauliflower. Maximum 3 applications per season.
				21	Cabbage. Maximum 3 applications per season.
parathion	organophosphate	Parathion 960E	375–590 mL	14	Not on kohlrabi, horseradish. Minimum period for re-entry is 7 days.
acephate	organophosphate	Orthene SP	0.75–1.1 kg	28	Maximum 4 applications per season. Not on broccoli, kale, kohlrabi, horseradish.

[1] Minimum period for re-entry is 24 hours.
[2] Minimum period for re-entry is 48 hours.

TABLE 5–14.
Aphid Control Recommendations for Cole Crops

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
dimethoate	organophosphate	Cygon 480 E	0.7–1.0 L	4	Cabbage, cauliflower, broccoli.
				21	Brussels sprouts.
			0.7 L	7	Kale.
		Lagon 480 E	0.7–1.0 L	4	Cabbage, cauliflower, broccoli.
				21	Brussels sprouts.
			0.7 L	7	Kale.
methamidophos[1]	organophosphate	Monitor 480 LC	1.1–2.25 L	7	Cabbage, cauliflower.
				14	Broccoli, Brussels sprouts.
naled	organophosphate	Dibrom EC	1.1 L	4	Not on kohlrabi, horseradish.
acephate	organophosphate	Orthene SP	0.75–1.1 kg	28	Not on broccoli, kale, kohlrabi, horseradish. Maximum of 4 applications per season.

[1] Minimum period for re-entry is 48 hours.

Tarnished Plant Bug

Both the adults and nymphs of this insect can damage the heads of broccoli and cauliflower. Brown beading of broccoli and brown streaking of cauliflower, may be caused by TPB feeding. If monitoring indicates a need, dimethoate (organophosphate group), as recommended for aphids (see Table 5–14, *Aphid Control Recommendations for Cole Crops,* above), and carbaryl (carbamate group), as recommended for caterpillars (see Table 5–13, *Cabbageworm, Cabbage Looper, Diamondback Moth Caterpillar Control Recommendations for Cole Crops,* on page 64), will help control tarnished plant bug in broccoli and cauliflower.

For more information, consult the OMAFRA Factsheet, *Tarnished Plant Bug Damage on Vegetable Crops in Ontario,* Order No. 98-025.

Cutworms

Cutworms are a very occasional problem in cole crops. If monitoring indicates a problem, consult the section *Cutworms* on page 16, for cutworm management recommendations.

Slugs

For slug control recommendations, see Table 5–12, *Root Maggot, Flea Beetle, Thrips and Slugs Control Recommendations for Cole Crops,* on page 63.

Nematode Control

See the section *Nematodes* on page 17 for nematode control recommendations.

Note

Consult *Integrated Pest Management for Crucifers in Ontario*, Order No. 701, for a complete guide to integrated pest management.

Visit the vegetable page on the OMAFRA Web site at http://www.gov.on.ca/OMAFRA/english/crops/hort/vegetable.html

TABLE 5–13.
Cabbageworm, Cabbage Looper, Diamondback Moth Caterpillar Control Recommendations for Cole Crops

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Bacillus thuringiensis	microbial	Dipel 2XDF	55–550 g	0	275–550 g for loopers.
		Thuricide HPC	2.0–4.25 L	0	Use higher rates for looper control, heavy infestations or when foliage is dense.
permethrin	pyrethroid	Pounce 384 EC	90–180 mL	3	Cabbage, cauliflower, Brussels sprouts.
				7	Broccoli.
fenvalerate	pyrethroid	Belmark 300 EC	150–325 mL	14	Cabbage, cauliflower, Brussels sprouts. Do not use on broccoli, kale, kohlrabi, horseradish.
deltamethrin	pyrethroid	Decis 5.0 EC	150–200 mL	3	Not on kohlrabi, horseradish.
cypermethrin	pyrethroid	Ripcord 400 EC	87.5–125 mL	3	Cabbage, cauliflower, broccoli, Brussels sprout only.
	pyrethroid	Cymbush 250 EC	140 mL	3	Cabbage, cauliflower, broccoli, Brussels sprout only.
cyhalothrin-lambda[1]	pyrethroid	Matador 120 EC	142 mL	1	Imported cabbageworm and diamondback moth larvae on cabbage.
				3	Imported cabbageworm and diamondback moth larvae on broccoli, cauliflower, Brussels sprouts.
			83 mL	1	Cabbage looper on cabbage.
				3	Cabbage looper on broccoli, cauliflower, Brussels sprouts.
methomyl[1]	carbamate	Lannate SP	270–540 g	1	Cabbage.
				7	Cauliflower, broccoli, Brussels sprouts.
carbaryl	carbamate	Sevin XLR Li	2.5–5.25 L	3	Cabbage and cauliflower.
				5	For broccoli and Brussels sprouts.
				7	For horseradish.
				21	Kale.
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	1.5–2.0 L	7	Not on kale, kohlrabi, horseradish.
		Thionex 400 EC	1.5–2.0 L	7	Not on kale, kohlrabi, horseradish.
naled	organophosphate	Dibrom EC	1.1–2.2 L	4	2.2 L rate for loopers only. Not on kohlrabi, horseradish.
methamidophos[2]	organophosphate	Monitor 480 LC	1.1–2.25 L	7	For cabbage, cauliflower.
				14	Broccoli, Brussels sprouts.
azinphos-methyl[2]	organophosphate	Guthion Solupak 50 WP	1.12–1.75 kg	7	Brussels sprouts. Maximum 3 applications per season.
				15	Broccoli and cauliflower. Maximum 3 applications per season.
				21	Cabbage. Maximum 3 applications per season.
		Guthion 240 SC	2.25–3.5 L	7	Brussels sprouts. Maximum 3 applications per season.
				15	Broccoli and cauliflower. Maximum 3 applications per season.
				21	Cabbage. Maximum 3 applications per season.
		Sniper 240 E	2.25–3.5 L	7	Brussels sprouts. Maximum 3 applications per season.
				15	Broccoli, cauliflower. Maximum 3 applications per season.
				21	Cabbage. Maximum 3 applications per season.
		Sniper 50 W Clean Pak	1.12–1.75 kg	7	Brussels sprouts. Maximum 3 applications per season.
				15	Broccoli & cauliflower. Maximum 3 applications per season.
				21	Cabbage. Maximum 3 applications per season.
parathion	organophosphate	Parathion 960E	375–590 mL	14	Not on kohlrabi, horseradish. Minimum period for re-entry is 7 days.
acephate	organophosphate	Orthene SP	0.75–1.1 kg	28	Maximum 4 applications per season. Not on broccoli, kale, kohlrabi, horseradish.

[1] Minimum period for re-entry is 24 hours.
[2] Minimum period for re-entry is 48 hours.

TABLE 5–14.
Aphid Control Recommendations for Cole Crops

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
dimethoate	organophosphate	Cygon 480 E	0.7–1.0 L	4	Cabbage, cauliflower, broccoli
				21	Brussels sprouts
			0.7 L	7	Kale
		Lagon 480 E	0.7–1.0 L	4	Cabbage, cauliflower, broccoli
				21	Brussels sprouts
			0.7 L	7	Kale
methamidophos[1]	organophosphate	Monitor 480 LC	1.1–2.25 L	7	Cabbage, cauliflower
				14	Broccoli, Brussels sprouts
naled	organophosphate	Dibrom EC	1.1 L	4	Not on kohlrabi, horseradish
acephate	organophosphate	Orthene SP	0.75–1.1 kg	28	Not on broccoli, kale, kohlrabi, horseradish. Maximum of 4 applications per season

[1] Minimum period for re-entry is 48 hours.

Tarnished Plant Bug

Both the adults and nymphs of this insect can damage the heads of broccoli and cauliflower. Brown beading of broccoli and brown streaking of cauliflower, may be caused by TPB feeding. If monitoring indicates a need, dimethoate (organophosphate group), as recommended for aphids (see Table 5–14, *Aphid Control Recommendations for Cole Crops*, above), and carbaryl (carbamate group), as recommended for caterpillars (see Table 5–13, *Cabbageworm, Cabbage Looper, Diamondback Moth Caterpillar Control Recommendations for Cole Crops*, on page 64), will help control tarnished plant bug in broccoli and cauliflower.

For more information, consult the OMAFRA Factsheet, *Tarnished Plant Bug Damage on Vegetable Crops in Ontario*, Order No. 98-025.

Cutworms

Cutworms are a very occasional problem in cole crops. If monitoring indicates a problem, consult the section *Cutworms* on page 16, for cutworm management recommendations.

Slugs

For slug control recommendations, see Table 5–12, *Root Maggot, Flea Beetle, Thrips and Slugs Control Recommendations for Cole Crops*, on page 63.

Nematode Control

See the section *Nematodes* on page 17 for nematode control recommendations.

Note

Consult *Integrated Pest Management for Crucifers in Ontario*, Order No. 701, for a complete guide to integrated pest management.

Visit the vegetable page on the OMAFRA Web site at http://www.gov.on.ca/OMAFRA/english/crops/hort/vegetable.html

CARROTS

Cultivars

Varieties listed in Table 5–15, *Carrot Cultivars*, below, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. In some cases, other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under Ontario growing conditions. Varieties of crops change frequently; check with a range of seed company representatives for additional recommendations and variety descriptions.

The carrot is a cool-season vegetable that is best adapted to areas with long, cool growing periods, free from extremes of temperature and moisture. The optimum mean temperature is between 16°C–21°C. High temperatures at the beginning of the growing season are injurious to the young plants. Continuous high temperatures in the latter stages of plant development may reduce yield, retard growth and produce a strong-flavoured, coarse root. Temperatures below 16°C will retard plant growth. The carrot is not tolerant to drought and requires steady and relatively large amounts of moisture for optimum growth. Good rainfall distribution or irrigation throughout the growing season is necessary to prevent a reduction in growth.

TABLE 5–15.
Carrot Cultivars

For cultivar susceptibility to rusty root (*Pythium* root dieback) and cavity spot, see the individual descriptions below.
Note: Cultivars are evaluated mostly on organic soils.

Cultivar	Description
Baby Carrot Types	
Baby Sweet Hybrid	
Minicor	Descriptions not available here; check seed catalogues.
Orange Delight	
Packaging and Bunching	
Canada Super X	Long, uniform roots, good internal and external colour, small core.
Cellobunch	Very high yield potential, medium long, susceptible to green shoulders.
First Class	Medium length, strong tops, good yields and colour.
HM 02	Uniform length, good internal colour, cylindrical in shape.
HM 03	Narrow shoulders, small internal core, strong tops, bolting tolerant.
Napoli	Slightly tapered, good orange interior colour, early.
Orange Pak	Good storage, good length, potential for oversize.
Orangette	Nice appearance, smooth, deep colour, slightly tapered roots, good length, good tops.
Six Pak and Six Pak II	Very long, very smooth and uniform, excellent colour, good yielding, good resistance to cavity spot and rusty root, tolerant to blight. Six-Pak II has excellent resistance to cavity spot.
Sunrise	Medium length, good yield, tolerant to leaf blight.
Processing	
Bergen	Full season, extra heavy yields, good tops, stores well.
Carson	Good interior colour, stores well.
Early Gold	Good tops, smooth Danvers type, good for dicing.
Exp 660	Heavy yields, strong tops, good colour, long Danvers shape, suitable for dicing.
Fayette	Strong tops, high yields, *Alternaria* tolerant, very good internal and external colour. Suitable for dicing.
Fontana	Smooth exterior, very good external and internal colour, heavy, thick, high yields, suitable for dicing. Susceptible to leaf blight.
Goliath	Smooth Chantenay X Danvers type, good internal colour, tolerant to cracking.
Heritage	Smooth exterior, cylindrical shape, good tops excellent colour, good yields, small core, suitable for dicing.
Magno	Excellent storage, good internal and external colour, strong tops.
Cut and Peel Types – Grow on mineral soil only; these cultivars do not perform well on muck soil for cut and peel.	
Diamond Cut	Mid-early maturing, long smooth roots, excellent colour, strong tops.
Enterprise	Good length, strong tops, smooth exterior.
HM 02	Uniform length, good internal colour, cylindrical in shape.
HM 03	Narrow shoulders, small internal core, strong tops, bolting tolerant.
Indiana	Long cylindrical shape, deep orange colour, does well at high plant stands.
Stylus	Very smooth, narrow shoulders, strong tops, sweet mild flavour.
Sugar Snax	Long, smooth roots, good flavour, semi-blunt tips, deep orange colour.

Soil

Deep, loose, fertile soils that have good water-holding capacity are necessary for the development of long, straight roots. Well-drained sandy loam, peat or muck are ideal for carrot production.

Seeding and Spacing

Time: As early as soil and weather conditions permit in the spring up to July 1. Late carrots may "burn off" if they emerge during hot, dry weather.

Rate: Fresh market: 2–4.5 kg/ha.
Processing: 1–2 kg/ha.

Depth: 1.2–2.0 cm.

Row Spacing: 55–85 cm depending on planting and harvesting machinery.

Raised Beds: Sowing carrots on raised beds (15–20 cm high) improves carrot quality. One system that has provided good results uses beds that are 85 cm wide at the bottom and 50 cm wide on top. Seed carrots in 3 or 4 rows on the centre of the bed at a rate to achieve 120–140 carrots/m for packaging carrots and 26 carrots/m for processing carrots.

Fertilizer

Nitrogen

On mineral soils, apply up to 110 kg N/ha. On muck soils, apply up to 60 kg N/ha. If manure is applied or legume sod is plowed down, reduce the nitrogen application. (See Table 3–10 and Table 3–11 on page 28 and page 29.)

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 3–5, Table 3–6 and Table 3–7 on page 24 and page 25.)

Application

On mineral soils, it is suggested to apply two-thirds of the nitrogen before planting and the balance side-dressed when plants are 10 cm tall. On muck soils, broadcast up to 60 kg N/ha before planting. Adjust the rate downward if tops have grown too vigorous in previous years.

Magnesium

Magnesium deficiency may occur on carrots. The usual symptoms are yellowing of older leaves while the veins remain dark green. Consult the section *Magnesium* on page 26, and Table 3–8, *Application Rates for Magnesium, Calcium and Micronutrients,* on page 26.

Micronutrients

Boron

Boron deficiency can cause necrosis in the growing tip or internal breakdown in carrot roots. Boron is recommended on new muck soils. Apply boron at 2.6 kg actual boron/ha with the fertilizer. Various sources of boron are available. Consult the section *Boron* on page 27 and Table 3–8 on page 26.

Copper

Copper deficiency may occur on acid peat and muck soils. It results in poor orange colour development in the carrot roots. Apply 14–29 kg copper/ha on new muck. Subsequent applications may be made every 2 or 3 years at about one-third the rate recommended for new muck. Consult the section *Copper* on page 27 and Table 3–8 on page 26.

Disease Management

Seed Decay, Damping-Off, Alternaria

Planting carrot seed treated with thiram (dithiocarbamate group) or iprodione (dicarboximide group) has resulted in improved stands.

Aster Yellows

The symptoms of aster yellows on carrots first appear as a reddening of several leaves, followed by excessive, yellow and brittle crown growth, followed by hairy root development. See the section *Aster Leafhoppers* on page 68.

Leaf Blight

If monitoring indicates a need, apply one of the fungicides recommended in Table 5–16, *Carrot Disease Control Recommendations,* on page 68.

A weather-timed spray program is available in areas where crop monitoring is provided. In this program, fungicide sprays are applied when:

1) Blight appears on 1–2% of the leaf area. This coincides roughly with the time when blight is first detectable.

2) After the first application, a recommended fungicide should be applied at 7- to 10-day intervals when weather is favourable for blight. The intervals between sprays are extended when the weather is unfavourable for blight. Lack of rainfall or cool nights (minimum temperature less than 15°C) are unfavourable for blight.

After the leaves have closed over the rows, spray at 7–10 day intervals.

TABLE 5–16.
Carrot Disease Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest
Leaf Blight				
mancozeb	dithiocarbamate	Manzate DF	2.25 kg	7
		Dithane M-45	2.25 kg	7
		Dithane DG	2.25 kg	7
		Penncozeb 75 DF	2.25 kg	7
zineb	dithiocarbamate	Zineb 80 W	3.25 kg	14
chlorothalanil	chloronitrile	Bravo 500 F	2.4–3.2 L	1
metiram	dithiocarbamate	Polyram 80 DF	2.25 kg	7
***Sclerotinia* Mould**				
benomyl[1]	benzimadazole	Benlate 50 WP	0.25–1.1 kg	15
Cavity Spot				
metalaxyl[2]	acylamine	Ridomil 2G	25 kg	215 g/100 m of raised bed

[1] Maximum of 3 applications/season.
[2] Apply product evenly with seed in the seed furrow.

For further information, consult the OMAFRA Factsheet, *Weather-Timed Sprays for Carrot Blight Control*, Order No. 98-051, and consult a crop specialist regarding blight assessments and blight-favourable weather.

Sclerotinia Mould (of carrots, lettuce, beans and celery)

Rotate with onions, beets or spinach for 2–3 years. Use wider row spacings to encourage good air movement. See the section *Commodity Compatibility* on page 46.

Field spraying can only be effective if the material contacts lower leaf petioles and crowns.

See Table 5–16, above, for control recommendations.

Rusty Root (Pythium Root Dieback)

Follow a 3-year rotation with unrelated crops, for example, onions. Avoid severely infested fields. Sow seed after the soil has warmed up in the spring and use disease-resistant cultivars. Establish uniformly spaced plant populations with precision-seeding equipment and avoid planting dense stands.

Violet Root Rot

This *Rhizoctonia* disease generally shows up in patches in the field and is characterized by soil sticking to the carrot root in a leathery-textured and purplish-coloured mass. Foliar symptoms may not always appear until the disease is serious, however, the carrot tops may wilt and die in the infected patches. Since the fungus causing this disease persists for several years and affects primarily carrots, the best control is to rotate with other crops, such as onions or crucifers. In addition, it is important not to spread soil from infested areas to non-infested areas or other fields.

Crown Rot

This disease is caused by a different species of *Rhizoctonia*. Diseased plants appear stunted and wilted in patches in the field. Horizontal, dark-brown lesions develop near the top of the root and may penetrate several millimetres deep. Infected crowns appear dry, rotten and dark brown. There are presently no known control methods other than crop rotation, improving drainage and early harvest. Consult the OMAFRA Factsheet, *Identification and Management of Carrot Root Diseases*, Order No. 98-001, for further information.

Cavity Spot

This disease is caused by several *Pythium* species and rarely reduces yield but can significantly affect quality. Research has shown that cultivars differ in susceptibility. Select cultivars that are least susceptible. (Consult the *Annual Vegetable Cultivar Trials and Research Report* published by the Muck Crops Research Station or with your seed company representatives). Avoid growing carrots in fields with a history of cavity spot. Crop rotation has not been effective in reducing this disease. See Table 5–16, above, for control recommendations.

Insect Management

Aster Leafhoppers

(See the sections *Aster Leafhoppers* on page 72 and page 87 for information on the Aster Yellows Index system.)

Leafhoppers spread the disease aster yellows. Winter grains are a major source of overwintering leafhoppers. Leafhoppers can be monitored with a sweep net to help determine when and if sprays are required. Without monitoring, there is no way to predict whether scheduled spraying with insecticides will provide any control. It is equally important to control weeds in headlands and ditchbanks, and control leafhoppers on adjacent celery and lettuce. If monitoring indicates a need, spray with one of the pesticides listed in Table 5–17, *Carrot Insect Control Recommendations*, on page 69, when the AYI reaches 50–100, depending upon variety.

Note: Rapid killing is obtained using parathion; slower but more lasting control is obtained with carbaryl.

TABLE 5–17.
Carrot Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Aster Leafhoppers					
carbaryl	carbamate	Sevin XLR Li	1.25–2.5 L	1	
parathion	organophosphate	Parathion 960 EC	375 mL	14	Minimum period for re-entry is 7 days.
Carrot Weevil					
phosmet	organophosphate	Imidan 50 WP	2.25 kg	40	Maximum 2 applications per season.
Carrot Rust Fly					
cypermethrin	pyrethroid	Cymbush 250 EC	280 mL	35	
diazinon	organophosphate	Diazinon 50 WP	1.1 kg	10	
		DZN 600 EW	0.915 L	10	
parathion	organophosphate	Parathion 960 EC	375 mL	14	Minimum period for re-entry is 7 days.

Carrot Weevil

Monitoring for the weevil greatly improves timing of sprays and determines whether they are needed. Spray when carrots are in the 2nd–3rd true-leaf stage. Repeat once 10–14 days later. Do not apply more than 2 times/season or later than 40 days before harvest. Spraying with phosmet may also reduce the carrot fly population. Consult the OMAFRA Factsheet, *Carrot Insects*, Order No. 93-077.

Carrot Rust Fly

This insect is mainly a problem in the Bradford area marshes and Crumlin marsh. Growers in other areas should consult a crop specialist before initiating a routine spray program. Consult a crop specialist for information on an IPM program or for up-to-date information on the timing of sprays. The first generation of flies is normally present from late May until late June, the second generation from late July until September. Consult the OMAFRA Factsheet, *Carrot Insects*, Order No. 93-077. If monitoring indicates a need, use one of the pesticides recommended in Table 5–17, *Carrot Insect Control Recommendations*, above.

Note: When flies are abundant, these sprays may not prevent damage to carrots growing adjacent to sheltered areas.

Cultural Practices

Carrots seeded after June 1 are rarely attacked by the first generation of the carrot rust fly. Carrots harvested by early September should escape most second generation damage. If possible, avoid growing carrots immediately adjacent to sheltered areas (such as the canal banks of the Holland Marsh).

Note: The OMAFRA publication *IPM for Onions, Carrots, Celery and Lettuce in Ontario*, Order No. 700, provides a comprehensive guide to IPM for carrots.

Cutworms

Cutworms are an occasional problem in carrots. If monitoring indicates a problem, consult the section *Cutworms* on page 16, for cutworm management recommendations.

Nematode Control

For nematode control recommendations, see the section *Nematodes* on page 17.

Storage

Mature topped carrots can be stored for up to 4–5 months at 0°C and a relative humidity of 90–98%.

Storage rots occur from infections of the carrot that occurred in the field or through wounds at harvest. Rapid cooling of carrots after harvest is very important in reducing storage rots.

Proper sanitation of the storage and handling equipment is necessary to help reduce infections. See the section *Sanitation* on page 47 for information on sanitation of storages. Also consult the OMAFRA Factsheet *Long-Term Storage of Carrots*, Order No. 98-073.

Visit the vegetable page on the OMAFRA Web site at http://www.gov.on.ca/OMAFRA/english/crops/hort/vegetable.html

CELERY

Cultivars

Varieties listed in Table 5–18, *Celery Cultivars*, below, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. In some cases, other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under Ontario growing conditions. Varieties of crops change frequently; check with a range of seed company representatives for additional recommendations and variety descriptions.

Seed Treatment

Buy hot-water-treated seed or sow 3-year-old seed to avoid seed-borne blight fungi. Treat seed with a protectant such as thiram (dithiocarbamate group), following manufacturer's instructions before sowing.

Growing Transplants

Sow seed in the greenhouse 10–12 weeks before field planting. About 140 g of seed provide enough plants for 1 ha when the standard field spacing is used.

The use of plug transplants allows machine transplanting and reduces transplant shock. Sow 1 seed per cell. Even watering and fertilization is critical in plug-plant production.

Until the plants emerge, a temperature of 21°C–24°C is suitable. Once plants have emerged, 18°C–24°C is suitable for steady growth. Night temperatures should not drop below 13°C to lessen the production of "seeders."

Plants for the early crop should not be set in the field until the danger of a prolonged cool period or actual freezing is over.

If the plants have become too tall and spindly before field setting, they can be clipped back to a height of 12–15 cm. Clipped plants facilitate transplanting, but well-grown, untrimmed plants are preferable because they receive less check in growth and are less susceptible to disease.

Plants for the late crop may be started in outdoor seedling beds if water is available for irrigation. The seed may be sown with a seed drill in rows 15–20 cm apart, at the rate of 80–110 seeds/m of row so that the stand will not need thinning before transplanting to the field, or seed may be broadcast in a finely prepared bed outdoors at the rate of 15 g/10 m^2. The first method provides sturdier plants.

Premature Seedstalk Development

The development of flowering shoots, called "bolting to seed," instead of the normal growth, is mainly due to exposure of young plants to temperatures below 13°C for 10 days or more.

The amount of bolting increases as the time of exposure is lengthened. Growers producing plants, especially for the early crop, should maintain greenhouse temperatures of 16°C–21°C. The plants can be hardened, if desired, by withholding water the last 7–10 days before setting in the field. Do not harden-off celery plants by lowering temperatures.

Spacing

The standard spacing is 15 cm apart in rows 50–55 cm apart.

Soil

Muck soil is ideal for celery production because of its high moisture-holding capacity. Celery may be grown successfully on well-drained mineral soil such as a sandy-loam, but irrigation will be necessary under these conditions. Rotation with other crops is an important aid in the control of diseases and insects.

TABLE 5–18.
Celery Cultivars

Note: Cultivars have been evaluated on muck soils.

Cultivar	Description
Florida 683	Medium-tall plants with medium-dark green foliage, relatively long heavy petioles and a well-developed heart. Susceptible to early bolting, no tolerance to *Fusarium* yellows. Suitable for storage.
Matador	Tall plants with smooth, long petioles, medium-green, good tolerance to *Fusarium* yellows.
Peto 285	Tall plant, good compactness, tolerant to *Fusarium* yellows, smooth petioles, not quite as bulky as Florida 683.
Picador	Tall, very uniform, dark green with long petioles. Best suited for processing. Good tolerance to *Fusarium* yellows.
Starlet	Large and somewhat spreading plants with long petioles, medium to light green foliage. Tolerant to *Fusarium* yellows. Quality will deteriorate if plants get over-mature.
Tall Utah 52–70 strains	Tall plants with medium- to dark-green foliage. Suitable for fresh market and processing.
Ventura	Tall plants with long petioles, dark-green colour, tolerant to bolting, suitable for early crop.

Fertilizer

Nitrogen

On mineral soils, apply a maximum of 195 kg N/ha. On muck soils, apply up to 160 kg N/ha with 80 kg/ha pre-plant and the remainder applied in 2 side-dressings of 40 kg/ha as required. If manure is applied or legume sod is plowed down, reduce the nitrogen application. (See Table 3–10 and Table 3–11 on page 28 and page 29.)

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 3–5 on page 24, and Table 3–6 and Table 3–7 on page 25.)

Application

Apply two-thirds of the nitrogen at planting time and the remainder side-dressed in 2 or 3 applications as required.

Secondary Nutrients and Micronutrients

Calcium

Calcium deficiency results in a physiological disorder known as "black heart," in which the celery heart turns black, while the outer leaves are unaffected. Spray directly into the heart of the plant with 1.0–1.8 kg calcium/ha from calcium chloride or calcium nitrate in 1,000 L water. If celery is under heat and moisture stress, reapply weekly.

Magnesium

Magnesium deficiency appears as chlorosis between the dark green veins of the older leaves. Some celery cultivars are inefficient in taking up magnesium from the soil. Apply a foliar spray of magnesium sulfate at rates supplying 1.0–2.0 kg magnesium/ha in 1,000 L water every 10–14 days starting when the plants are about one-third grown.

Boron

Boron deficiency results in a physiological disease known as "cracked stem" or "cat scratches." Apply 1–3 kg boron/ha (2–6 kg/ha on muck soils) with the fertilizer, and a foliar spray of 0.1–0.3 kg boron in 1,000 L water. Spray when the young plants are about 15 cm tall. Subsequent applications may be required.

Disease Management

Early Blight (Cercospora), Late Blight (Septoria), Bacterial Blight

Use a commercial soilless mix or heat-pasteurized soil for growing seedlings in plug trays or flats. Rotate outdoor seedbeds. Use 3-year-old or hot-water-treated seed. Check seedlings for signs of disease and discard any seedlings with symptoms of blight. Do not transplant diseased seedlings into the field. Start spraying or dusting when seedlings are about 5 cm high and apply one or two applications before transplanting. After transplanting, begin fungicide application when plants are one-third grown or when the first signs of disease are detected. Regular treatments based on careful monitoring will be required throughout the season.

Spray with one of the fungcides recommended in Table 5–19, *Celery Blight Control Recommendations*, below.

Aster Yellows

The symptoms of aster yellows on celery first appear as bright yellowing of several leaves, followed by excessive, brittle, yellow crown growth. Severe twisting and secondary bacterial infections follow. Roguing out infected plants is an effective way to reduce in-field sources of disease.

See the section *Aster Leafhoppers* on page 72.

TABLE 5–19.
Celery Blight Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Early Blight, Late Blight, Bacterial Blight					
mancozeb	dithiocarbamate	Dithane DG	2.25 kg	14	Wash and trim.
		Dithane M-45	2.25 kg	14	Wash and trim.
		Manzate DF	2.25–3.25 kg	14	Wash and trim.
		Penncozeb 75 DF	2.25 kg	14	Wash and trim.
metiram	dithiocarbamate	Polyram 80 DF	2.25 kg	14	After transplanting.
zineb	dithiocarbamate	Zineb 80 W	2.25–3.25 kg	14	
copper sulphate	inorganic	Copper 53 W	3.25–6.50 kg	1	
copper oxychloride	inorganic	Copper Spray 50 W	4.0 kg	1	
chlorothalanil	chloronitrile	Bravo 500	1.6–2.4 L	7	On a 3–5 day schedule.
			2.4–4.0 L	7	On an 8–10 day schedule.

Fusarium Yellows

This fungus persists in soil for many years. Avoid introducing it by preventing the movement of infested plants or soil from other farms or areas where the disease occurs. The fungus may be introduced in or on transplants and attached soil, in infested soil carried by floodwater, by wind from infested fields nearby, by workers, tools and implements. If the disease is present, start seedlings in soilless media or fumigated soil and plant in fields where the disease has not occurred before. Sanitation is important in preventing the spread of this disease.

Avoid cultivation practices that can spread infested soil from one area to the rest of the field. Do not return celery trimmings to infested fields after harvest. Practice a 2- to 3-year rotation with onions or lettuce to reduce spore populations in infested fields. Avoid the use of carrots in the rotation scheme. Starlet, Matador and Picador cultivars are resistant to the disease, while Utah 52-70HK and Peto 285 are tolerant to the disease when soil population levels of the fungus are moderate. Excessive heat and drought stress may diminish this tolerance. Other cultivars may be susceptible to this disease. For more details, consult the OMAFRA Factsheet, *Fusarium Yellows of Celery,* Order No. 98-061, or consult with your seed company representative.

Pink Rot (Sclerotinia White Mould)

Pink rot is an occasional problem during wet seasons. A white-pinkish mould develops on lower petioles and may be followed by rapid secondary rots. No fungicides are labeled for control of this disease, however, cultural practices as suggested for carrot (see page 68) and lettuce (page 85) may be helpful.

Cucumber Mosaic Virus

Aphids vector the mosaic virus by picking up the disease from infected weeds. Control weeds bordering the crop area. Rogue out plants if mosaic infection is noticed early in the season. Keeping aphids under control may reduce the spread of the virus.

Insect Management

Consult the label before combining any insecticide with copper sulphate.

Aster Leafhoppers

Control leafhoppers because they spread aster yellows. Leafhoppers can be monitored with a sweep net and sticky traps to help determine when and if sprays are required. Without monitoring, there is no way to predict whether scheduled spraying with insecticides will provide any control. In addition, control weeds in headlands and ditchbanks and control leafhoppers on adjacent carrots and lettuce. To help slow down the rate of resistance, alternate the use of insecticides from the various groups. To use the Aster Yellows Index (AYI), monitor aster leafhoppers with a sweep net. Multiply the number of aster leafhoppers captured in 100 sweeps by the percentage of leafhoppers carrying aster yellows in your area. Treat when the AYI equals 20–25 for head lettuce and 30–35 for celery and romaine. Use this formula:

$$\frac{\text{\# leafhoppers}}{\text{100 sweeps}} \times \text{\% infectivity} = 30\text{–}35$$

For more details, consult the OMAFRA Factsheet, *The Aster Leafhopper and Aster Yellows,* Order No. 98-057.

If monitoring indicates a need, spray with one of the insecticides recommended in Table 5–20, *Celery Insect Control Recommendations,* on page 73.

Carrot Weevil

Carrot weevil can seriously damage celery roots and the crown, causing stunting and plant collapse. See the section *Carrot Weevil* on page 69, for monitoring information and Table 5–20 on page 73 for control recommendations.

Tarnished Plant Bug

Monitoring for the adult TPB and the nymphs will help improve control. Check at least 50–100 plants randomly in the field. Adults will fly in short, quick bursts, and the green nymphs will run quickly from the plants, making monitoring difficult. Thresholds are based on growth stage and numbers of TPB per plant. When threshold levels of 0.1–0.2 TPB per plant are reached, apply the insecticides recommended in Table 5–20 on page 73.

For more information, consult the OMAFRA Factsheet *Tarnished Plant Bug Damage on Vegetable Crops in Ontario,* Order No. 98-025.

Aphids

Monitoring can help confirm when and if sprays are required. Check 50–100 plants and record the number of plants infested with aphids. Note also the average number of aphids per plant. Also note that the sunflower aphid and the green peach aphid may have developed resistance to insecticides in some areas.

Consult the OMAFRA Factsheet *Aphids Infesting Lettuce and Celery in Ontario,* Order No. 93-073. If monitoring indicates a need, spray with one of the pesticides recommended in Table 5–20 on page 73.

Cabbage Looper

This is a rare problem in Ontario celery, however it can cause sporadic damage. Check plants randomly in the

TABLE 5–20.
Celery Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Aster Leafhopper					
cypermethrin	pyrethroid	Cymbush 250 EC	140 mL	7 days	
parathion	organophosphate	Parathion 960 EC	225–375 mL	14 days	To avoid excessive residues, do not use parathion more than twice during the growing season. Minimum period for re-entry is 7 days.
malathion	organophosphate	Malathion 500 E	2.25 L	7 days	
carbaryl	carbamate	Sevin XLR Li	1.25–2.5 L	5 days	
Carrot Weevil					
phosmet	organophosphate	Imidan 50 WP	2.25 kg	40 days	
Tarnished Plant Bug					
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.75 kg	14 days	Trim the celery of all outer leaves.
		Thiodan 4 EC	2.0 L	14 days	
		Thionex 400 EC	2.0 L	14 days	
acephate	organophosphate	Orthene 75 SP	0.75–1.1 kg	21 days	
Aphid					
naled	organophosphate	Dibrom EC	1.1–1.65 L	4 days	
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.75 kg	14 days	Trim the celery of all outer leaves.
		Thiodan 4 EC	2.0 L	14 days	
		Thionex 400 EC	2.0 L	14 days	
acephate	organophosphate	Orthene 75 SP	0.75–1.1 kg	21 days	Green peach aphid only.
Cabbage Looper					
Bacillus thuringiensis	microbial	Thuricide HPC	2.0–4.25 L	0 days	
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.75 kg	14 days	Trim the celery of all outer leaves.
		Thiodan 4 EC	2.0 L	14 days	
		Thionex 400 EC	2.0 L	14 days	
naled	organophosphate	Dibrom EC	1.1–1.65 L	4 days	

field and record the percentage of plants infested. Five per cent infestation is suggested as a threshold guideline. If monitoring indicates a need, apply one of the pesticides recommended in Table 5–20, above.

Leaf Miner

This is also a rare problem in Ontario celery. Severe damage to leaves can reduce the photosynthetic ability of the plants and impede water movement leading to leaf drop. Leaf miner damage may reduce the marketability of fresh market celery. Consult the OMAFRA Factsheet *Leafminers Attacking Field Vegetables and Greenhouse Crops*, Order No. 00-039. No thresholds for leafminers on celery are established, however, if monitoring indicates a need, only parathion as recommended above for aster leafhoppers is labeled.

Cutworm

Cutworms are an occasional pest of celery both early in the season and sometimes later in the season, when climbing cutworm species seriously damage celery petioles. If monitoring indicates a problem, consult the section *Cutworms* on page 16 for cutworm management recommendations.

Note: The OMAFRA Publication *IPM for Onions, Carrots, Celery and Lettuce in Ontario*, Order No. 700, provides a comprehensive guide to IPM for celery.

Nematode Control

For nematode control recommendations, see page 17.

Caution

Some individuals may be sensitive to the natural chemicals found in celery. These substances increase if celery is diseased. Using rubber gloves when handling celery and leg protection when walking in the field will prevent the development of skin rashes.

Storage

Do not store celery that has been badly damaged by frost, disease or handling. A relative humidity of 95–98% and a temperature of 0°C are ideal. Celery should be stored in a room that is free from odours, because the plant absorbs foreign flavours. Field heat should be removed by hydrocooling or vacuum-cooling, before placing in large storage rooms.

CUCURBITS:
CUCUMBER, MUSKMELON, WATERMELON, PUMPKIN, SQUASH (ALSO KNOWN AS VINE CROPS)

Cultivars

The varieties listed in Table 5–21, *Cucurbit-Crop Cultivars*, below, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. In some cases, other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under Ontario growing conditions. Varieties of crops change frequently; check with a range of seed company representatives for additional recommendations and variety descriptions.

Note on Processing Cucumbers

All the cultivars listed are hybrids that have a predominately female flowering habit. A true gynoecious cucumber bears only female flowers. However, not all hybrids produce 100% female flowers. As many as 80% of the plants of many new hybrids may have some male flowers in Ontario fields. Ontario day-lengths and temperatures may be responsible for the presence of male flowers on these hybrids. From 10–15% of the seed sold as a gynoecious hybrid is a standard or monoecious cultivar, added as a pollinator. For satisfactory fruit set, 10–20% of the plants should contain a large number of male flowers.

The cultivars listed in Table 5–21 are recommended based on their suitability for either hand-pick or once-over mechanical harvesting. The hand-pick cultivars have performed well in trials and on growers' fields over the past several years. All of the machine harvest cultivars were bred especially for once-over harvesting of high plant populations.

TABLE 5–21.
Cucurbit-Crop Cultivars

CUCUMBER	MUSKMELON	WATERMELON[1]	PUMPKIN	SQUASH (WINTER)	SQUASH (SUMMER)
Fresh	Cordelle	***Seedless Type***	***Large (6–10 kg)***	***Buttercup***	***Marrow***
Dasher II	Early Dawn	Millionaire	Magic Lantern PMT[2]	Sweet Mama (cupless)	Vegetable Marrow Bush
Greensleeves	Rising Star	Crimson Trio	Jack-O-Lantern		Ghada
Speedway	Athena[3]	King-of-Hearts	Pankow's Field	***Butternut***	
Jazzer	Pulsar	Tiffany	Howden	Supreme	***Straight Neck***
Turbo	Starfire	Constitution	Merlin PMT[2]	Ultra	Fortune
General Lee	Superstar		Goldrush		Sunray
	Summet[4]	***Icebox (Round) Types***	Ol' Zeb	***Delicious***	General Patton
Processing – Hand Pick	Sugarbowl	Sugar Baby	Pro Gold 510	Golden Delicious	
Bradley C	Eclipse	Jade Star		Green Delicious	***Scallop***
Fancipak		Tiger Baby	***Medium (3–5 kg)***		White Bush Scallop
Flurry M		Sugar Doll	Mystic	***Acorn (Pepper)***	Peter Pan (Light Green)
Vlasset B			Jack-of-all-trades	Taybelle PM	Sunburst (Yellow)
Patton		***Yellow/Orange Flesh Types***	Wizard	Table Queen (late)	
Pik-Rite		New Queen (round)	Ghost Rider	Mesa Queen	***Zucchini (green)***
Score		Yellow Doll (round)			Elite
Triplemech		Solid Gold (round)	***Small (1–2 kg)***	***Novelty Squash***	Select
		Treasure Chest (seedless)	Spooktacular	Pink Banana	Embassy
Processing – Once-Over		Triton (seedless)	Oz	Spaghetti	Tigress ZYMV[5]
Atlantis		Honey Heart (Oblong)	Small Sugar	Large Turks' Turban	
Discover M					***Zucchini (yellow)***
Lafayette		***Picnic (Oblong) Types***	***Mini***	***Sweet Potato***	Gold Finger
Napoleon		Sangria	Sweetie Pie	Delicata (long)	Gold Rush
Royal		Royal Sweet	Baby Boo (white)	Sweet Dumpling (round)	
Vlaspik M		Stars n' Stripes	Munchkin		
		Fiesta	L'il Goblin	***Hubbard***	
		Sentinel	L'il Ironsides	Kitchenette	
		Mardi Gras		Mini-Green	
		Oasis			
		Paradise			

[1] Availability is subject to WFB (Watermelon Fruit Blotch) certification.
[2] PMT = Powdery mildew-tolerant
[3] Tolerant to *Fusarium*.
[4] Resistant to powdery mildew.
[5] Tolerant to zucchini yellows mosaic virus.

Seed Treatment

Treat seed with a fungicide such as thiram (dithiocarbamate group) or captan (phthalimide group) according to the manufacturer's directions.

Seeding and Spacing

Cucumber

About 2.2 kg of seed are required to produce enough cucumber transplants for one hectare. For direct seeding of cucumbers, 4.5–5.5 kg of seed/ha are required.

Cucumber (Fresh)

Rows 1.2–1.8 m, plants 30 cm apart.

Cucumber (Processing)

For the hand-harvested crop, rows are usually spaced 1.1–1.2 m apart with 6–10 plants per metre of row, which produces plant populations ranging from 50,000 to 90,000 plants/ha.

These spacings require from 1.7–3.0 kg of cucumber seed per ha. With average germination conditions, 1.0 kg of cucumber seed will give approximately 30,000 plants. Close spacing (rows 75 cm apart) has been successfully used by some growers. In general, the closer the spacing, the higher the yield. However, very close spacing may present problems at harvest due to excessive vine, depending on cultivar, soil type and amount of rainfall.

For the once-over machine-harvested crop, the plant population for optimum yield will depend on soil type and availability of irrigation. Without irrigation, populations of 150,000/ha are adequate. This population can be achieved by spacing rows 70 cm apart with 10 plants/m of row and will require 5.0 kg of seed/ha.

Higher populations, up to 200,000 plants/ha, can be achieved by spacing rows 50 cm apart with 10 plants/m of row, requiring approximately 7.0 kg of seed/ha.

Muskmelon

About 2.2 kg of seed are required to produce enough muskmelon transplants for one hectare. For direct seeding of melons, 4.5–5.5 kg of seed /ha are required.Plant rows 1.5–1.8 m apart and plants 60–120 cm apart.

Pumpkin (Bush) and Summer Squash

Rows 90–120 cm apart, plants 60–90 cm apart.

Pumpkin (Standard) and Winter Squash

Rows 1.8–2.5 m apart, plants 90–120 cm apart.

Squash and Pumpkin

Seeding rates vary somewhat with seed size. Large-seeded cultivars such as blue hubbard will require 3.5–4.5 kg/ha and small-seeded cultivars such as butternut will require 1–1.5 kg/ha.

Watermelon

Rows 1.8–2.5 m, plants 90–120 cm apart.

Planting Processing Cucumbers

Pickling cucumbers are usually field-seeded from late May to early June for the hand-pick crop, but for once-over mechanical harvesting, seeding can be done until mid-July. Quick uniform emergence is essential to avoid uneven stands and stands weakened by insects and disease. Because of a more-uniform depth of seeding and spacing of the seed, precision seeding tends to reduce plant stress and promote more uniform crop emergence and development. Cucumber seeds will not germinate at a soil temperature below 10°C, will germinate slowly at 20°C and will germinate fastest at 25°C–30°C soil temperature. Delay seed sowing until the soil temperature is 15°C or higher. Seeding depth will vary depending on moisture. A soil cover of 2.0–2.5 cm is usually adequate. Cucumber seed should never be planted deeper than 2.5 cm.

Producing Melon and Cucumber Transplants

Crops of melons, cucumber and zucchini may be established from transplants to promote early maturity. Transplants should be grown in plug-type trays to reduce root damage at transplanting. Large containers such as 24- or 38-cell trays may be used to produce a better quality, earlier transplant.

Vine crops should be germinated between 26°C–30°C in the greenhouse or germination chamber. Night temperatures during seedling growth should not fall below 10°C, or chilling injury may result.

Vine crop transplants should not be excessively large at planting. A 3–4-week-old seedling with 3–5 true leaves is optimum for rapid field establishment. A starter solution such as 10-34-0 at 1 L/150 L of transplant water should be used. Young vine crop transplants are very susceptible to damage by wind and sandblasting. Transplants can be protected by using row covers or windbreaks such as rye strips.

Consult the OMAFRA Factsheet, *Muskmelon Production*, Order No. 89-101.

Plasticulture for Vine Crops

Consult the section *Plasticulture* on page 42.

Seedless Watermelon Production

Seedless (triploid) watermelons may be popular items for roadside stands and local markets, but production will be limited to areas of the province with longer growing seasons. Most seedless watermelon varieties mature in 75–90 days from transplanting, and produce round-to-oval fruit that average 5–8 kg in weight.

Transplants

Seedless watermelon transplants should be grown in large containers (24-cell trays or 10-cm pots). Seed should be germinated at high temperatures (24°C–27°C). Avoid over-watering the growing media. Transplants should be about 4 weeks old (usually 4 true leaves) when transplanted into the field.

Pollination

Triploid watermelons will not set fruit unless pollinated by a normal (diploid) watermelon variety. Interplant the pollinator variety with 2 rows of the seedless variety to 1 row of the pollinator. Plant a pollinator with a different fruit type to distinguish it from the seedless variety at time of harvest. Provide bees for pollination. Under cool growing conditions, some seed development may occur in seedless watermelons.

Field Planting

Plastic mulch is recommended to improve early growth, control weeds and keep fruit clean. In short-season areas, plastic row covers may be used to extend the growing season. A uniform moisture supply is needed to prevent development of hollow fruit.

Pollination

All the vine crops depend on insects to transfer pollen from the male to the female blossoms, which are borne separately on the same plant. In small plantings, there may be enough native pollinating insects to perform this function. In large plantings, the grower is advised to introduce one colony of honeybees for every hectare to ensure adequate pollination. Insecticides will poison bees. See the section *Bee Poisoning* on page 8. Consult the OMAFRA Factsheet, *Pollination of Vine Crops*, Order No. 87-043.

Fertilizer

Nitrogen

Apply up to 110 kg N/ha. If manure is applied or legume sod is plowed down, reduce the nitrogen application. (See Table 3–10 and Table 3–11 on page 28 and page 29.)

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 3–5, Table 3–6 and Table 3–7 on page 24 and page 25.)

Application

Before planting, broadcast 65 kg N/ha and all of the phosphate and potash required and work in. Alternatively, up to 100 kg of ($N + K_2O$)/ha can be applied in a band, 5 cm to the side and 5 cm below the seed at planting with the remainder of the fertilizer broadcast before planting. The remainder of the N should be side-dressed before the vines begin to run. On sandy soils, a second application may be necessary after the vines begin to run, especially following heavy rains.

Irrigation

If the nitrogen is applied through the irrigation system, no more than 20 kg N/ha per application should be used.

Disease Management

Damping-Off

Treat seed with a captan (phthalimide group) or thiram (dithiocarbamate group) seed protectant. Sterilize soil for growing seedlings.

Bacterial Wilt

The causal bacteria overwinter in the stomach of adult cucumber beetles, which vector this disease. Plants may become infected soon after they emerge when the crop is field seeded, or after transplants are set in the field and for the following 3–5 weeks. Beetles must be controlled (see the section *Striped Cucumber Beetle, Spotted Cucumber Beetle (aka Southern Corn Rootworm)* on page 78).

Angular Leaf Spot (Cucumber)

It is not possible to completely control this disease with fungicides. A reduction in disease severity may be achieved by spraying with a copper fungicide. Repeat at weekly intervals in wet weather. Do not work in crop when foliage is wet. See Table 5–22, *Cucurbit Disease Control Recommendations*, on page 77, for pesticide recommendations.

Fusarium Wilt (Muskmelon)

Sterilize soil for melon transplants. Grow *Fusarium*-resistant cultivars in infested soils (consult seed catalogues).

Mosaic (Virus)

Grow cultivars reported to be highly resistant to mosaic (cucumber cultivars show a range of resistance). Consult seed catalogues. Since the virus is transmitted by aphids and cucumber beetles, monitor for them carefully and

TABLE 5–22.
Cucurbit Disease Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Angular Leaf Spot (Cucumber)					
copper sulphate/ copper hydroxide	inorganic	Copper 53 W	2.5–3.0 kg	1	
		Kocide 101 WP	2.25–3.25 kg	1	
		Copper Spray WP	4.0 kg	1	
		Champion 50 WP	2.25–3.25 kg	1	
Scab (Cucumber)					
chlorothalanil	chloronitrile	Bravo 500 F	4.8 L	1	
mancozeb	dithiocarbamate	Dithane DG	1.1– 3.25 kg	14	
		Dithane M-45	1.1–3.25 kg	14	
		Manzate DF	2.25–3.25 kg	14	
		Penncozeb 75 DF	1.1–3.25 kg	14	
benomyl	benzimadazole	Benlate 50 WP	550–850 g + mancozeb (above)	14	
captan	phthalimide	Maestro 75 DF	2.5–4.5	2	
		Captan 80 W	2.25–4.25 kg	2	
		Supra Captan 80 WDG	2.0–4.2 kg	2	
Anthracnose					
chlorothalanil	chloronitrile	Bravo 500 F	4.8 L	1	
mancozeb	dithiocarbamate	Dithane DG	1.1–3.25 kg	14	
		Dithane M-45	1.1–3.25 kg	14	
		Manzate DF	2.25–3.25 kg	14	Cucumbers only.
		Penncozeb 75 DF	1.1–3.25 kg	14	
captan	phthalimide	Maestro 75 DF	2.5–4.5 kg	2	Cucumbers only.
		Captan 80 W	2.25–4.25 kg	2	Cucumbers only.
		Supra Captan 80 WDG	2.0–4.2 kg	2	Cucumbers only.
Powdery Mildew					
chlorothalanil	chloronitrile	Bravo 500 F	4.8 L	1	
benomyl	benzimadazole	Benlate 50 WP + mancozeb (above)	550–750 g + mancozeb (above)	14	

apply recommended materials to control them (see the section *Aphids* on page 78). Because the virus overwinters in such perennial weeds as milkweed, ground cherry, pokeweed and mother-wort, destroy nearby weeds in fencerows and waste areas.

Alternaria Leaf Spot

This disease is often prevalent in muskmelons. The oldest leaves are infected first. Sprays applied to control scab and anthracnose are somewhat effective.

Scab (Cucumber)

Where susceptible cultivars are grown, scab is often serious. If they are available, plant scab-resistant cultivars. Do not plant cucumbers following cucumbers. Beyond the seedling stage, spray with one of the fungicides recommended in Table 5–22, above.

Anthracnose

Do not plant melons following melons. Spray seedlings as described above for control of scab on cucumbers. Beyond the seedling stage, spray with one of the fungicides recommended in Table 5–22, above.

Powdery Mildew

Some cucumber and muskmelon cultivars are moderately resistant to mildew. As soon as mildew appears, spray with one of the fungicides recommended in Table 5–22, above, at 8- to 10-day intervals:

Insect Management

Squash Vine Borer (On Squash)

Fleshy, white larvae feed inside stems and fruit. If monitoring indicates a need, 4 insecticide applications, 1 week apart, starting in late June are required. Spray the base of plants thoroughly with one of the insecticides recommended in Table 5–23, *Cucurbit Insect Control Recommendations*, on page 78.

Seed Maggots, Wireworms and Seed Decay

Treat seed with diazinon (organophosphate group), lindane (polychlorocycloalkane group) and a fungicide. See the section *Chemical Seed Treatment* on page 11.

TABLE 5–23.
Cucurbit Insect Control Recommendations

Common Name	Group	Trade Name	Rate	Days to Harvest	Notes
Squash Vine Borer (Squash)[1]					
Spray					
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.0 kg/ha	2	
		Thiodan 4 EC	1.5 L/ha	2	
		Thionex 400 EC	1.5 L/ha	2	
rotenone	botanical	Rotenone 5 WP	4.5 kg/ha	1	
Dust					
rotenone	botanical	Rotenone 1% WP	40 kg/ha	1	
Cucumber Beetles					
Spray					
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.0 kg/ha	2	
		Thiodan 4 EC	1.5 L/ha	2	
		Thionex 400 EC	1.5 L/ha	2	
azinphos-methyl	organophosphate	Guthion 240 SC	2.25 L/ha	6	**Cucumbers** 7 days between applications Maximum of 3 applications per season.
		APM 50 WP	1.1 kg/ha		
		Sniper 240 E	2.25 L/ha		
		Guthion Solupak 50 WP	1.12 kg/ha	14	**Melons and pumpkins:** 5 days between applications Maximum of 2 applications per season. Minimum period for re-entry is 48 hours.
methoxychlor	diphenylethane	Methoxychlor 50 W	1.7–5.0 kg/ha	1	Do not use on melons.
Dust					
rotenone	botanical	Rotenone 1% WP	40 kg/ha	1	
Aphids					
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.0 kg/ha	2	
		Thiodan 4 EC	1.5 L/ha	2	
		Thionex 400 EC	1.5 L/ha	2	
malathion	organophosphate	Malathion 25 W	4.25 kg/ha	3	
			4.0–5.5 kg/ha	3	Melon
		Malathion 500 E	1.8 L/ha	3	
Two-Spotted Spider Mite					
dicofol	diphenylethane	Kelthane 50 W	1.0–1.25 kg/ha	7	

[1] Butternut squash is resistant to squash vine borer.

Cutworms

See the section *Cutworms* on page 16 for cutworm control recommendations.

Striped Cucumber Beetle, Spotted Cucumber Beetle (aka Southern Corn Rootworm)

The striped cucumber beetle is yellow with 3 distinct black stripes and is 5 mm long. The spotted cucumber beetle is also 5 mm long, greenish-yellow with 12 dark spots.

Monitor 50–100 plants across the entire field area, especially when plants are small (fewer than 5 leaves). Border treatments may be effective when beetles first appear. Thresholds vary across North America, however, for cucumbers and muskmelons, a general guideline is to treat when beetles exceed 0.5–1 per plant. For pumpkin, squash and watermelon, which are less susceptible, treat when beetles exceed 5 per plant.

If monitoring indicates a need, spray or dust when plants are breaking through with one of the pesticides recommended in Table 5–23, above. Repeat if beetles reappear.

Aphids

Aphids are vectors of virus diseases. Focus monitoring efforts on runners. If monitoring indicates a need, spray with one of the pesticides recommended in Table 5–23, above. Spot treatments and biological controls are effective in most cucurbit crops.

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Leafhoppers

If monitoring indicates a need, spray or dust with methoxychlor (diphenylethane group), rotenone (botanical group), or malathion (organophosphate group) at the rates given for other insects.

Squash Bug

The squash bug is primarily a pest of pumpkin, squash and zucchini, but can be found on any cucurbit crop. The squash bug overwinters as an adult in sheltered areas and during mid-summer will emerge to lay bright, yellow eggs in clusters on the undersides of leaves. The nymphs are pale when they first hatch but turn grey within a few days. Both the nymphs and adults suck sap from the leaves, stems and fruit. Adults are flat, greyish-brown bugs, about 1.5 cm long. Crop rotation and field sanitation are the best methods for managing this pest.

Two-Spotted Spider Mite

If monitoring indicates a need, spray as recommended in Table 5–23 on page 78.

Sap Beetles (Melons)

Beetles infest and damage ripening fruit where the stem is attached to the vine and where the skin is diseased or injured. To reduce beetle injury, harvest the melons as often as possible at the half-slip stage. Remove all damaged fruit and culls from the field.

Western Corn Rootworm Beetles

This species may also attack cucurbits later in the season. Methods used to control cucumber beetles will also provide short-term control of corn rootworms.

Nematode Control

For nematode control recommendations, see the section *Nematodes* on page 17.

Curing and Storing Pumpkin and Squash

Most pumpkins do not keep as well as hard-shelled winter squashes but if properly handled, they can be kept until after Christmas. All winter squashes should be well matured, carefully handled and free from injury or decay when stored. Unlike most other vegetables, squashes and pumpkins require warm, fairly dry storage with good air circulation. The fruit can be placed, preferably on racks, leaving a small space between each fruit or they can be placed in bulk bins and baskets. Pumpkins and winter squashes are best stored at 10°C–13°C with a relative humidity (RH) of 50–70%. Temperatures that are too low in storage will cause a very rapid breakdown and rotting of fruit.

Butternut squashes should keep 2–3 months at 10°C with 50% RH, after which time spoilage and shrinkage increase. Weight loss should be kept below 15%. Buttercup squashes should keep at least 3 weeks. Hubbard squashes can be stored up to 6 months at 10°C–13°C with 70% RH.

Curing the fruit for 10–20 days at 24°C–27°C can decrease its higher water content and improve its eating quality. Butternut, hubbard and delicious cultivars respond to this treatment, but storage life may be shortened. Curing acorn-type squashes decreases the storage life and eating quality.

Bee Warning

Except for rotenone, these insecticides are toxic to bees. Apply insecticides other than rotenone early in the day or in the evening when bees are not working in the field. If hives are in the crop, remove them when treating the field.

Visit the vegetable page on the OMAFRA Web site at http://www.gov.on.ca/OMAFRA/english/crops/hort/vegetable.html

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EGGPLANT

Cultivars

The varieties listed in Table 5–24, *Eggplant Cultivars,* right, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. In some cases, other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under Ontario growing conditions. Varieties of crops change frequently; check with a range of seed company representatives for additional recommendations and variety descriptions.

TABLE 5–24.
Eggplant Cultivars

Bell Types	Cylindrical Types	Sicilian Types
Highbush Select	Mirabel	Murena
Classic	Vernal	Black Bell
Epic	Mini Fingers	Black Beauty
Night Shadow	Rosita	Italian Pink
Special Hibush		Bicolour
Dusky		
White	**Mini**	
Ghost Buster	Baby Bell	
Casper		

Seed Treatment

Sow hot-water-treated seed (see the section *Hot-Water Treatment* on page 11). Before sowing, dust seed with thiram (dithiocarbamate group) seed protectant.

Seed and Spacing

Rate: 200–300 g of seed will produce enough plants for 1 ha.

Row Spacing: Rows 90–120 cm apart; plants 45-60 cm apart in the row.

Growing Eggplant Transplants

Eggplant crops should be established from greenhouse-grown plug transplants. Larger cell sizes, such as 72-, 98- or 128-cell trays are recommended for better stand establishment and earlier crops. A soilless growing media should be used in the trays. Eggplant should be germinated at a temperature of 27°C–29°C. Night temperatures during seedling growth should not fall below 10°C, or chilling injury may result. For further details on transplant production practices, consult the OMAFRA Factsheet, *Growing Vegetable Transplants in Plug Trays,* Order No. 96-023.

Fertilizer

Nitrogen

Apply up to 70 kg N/ha. If manure is applied or legume sod is plowed down, reduce the nitrogen application. (See Table 3–10 and Table 3–11 on page 28 and page 29.)

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 3–5, Table 3–6 and Table 3–7 on page 24 and page 25.)

Application

Broadcast 35 kg N/ha and all of the phosphate and remainder of the nitrogen should be side-dressed, 3–4 weeks after field setting.

Starter Solution

At transplanting, apply a starter solution high in phosphorus such as 1 L of 10-34-0 per 100 L of water or 1 L of 6-24-6 per 75 L of water. Under high temperature conditions or on dry sandy soils, reduce the amount of fertilizer by one-half but continue to use the same volume of water. This will reduce the risk of crop injury under these growing conditions.

Disease Management

Damping-Off

See the section *Seed Treatment* on page 80. Sow and transplant in steamed or fumigated soil. Drench flats at time of first watering with Captan 50 WP (see label). When first true leaves develop, spray with captan (phthalimide group) and repeat every 7–10 days. Apply sufficient spray to wet the plants and run down the stems. (See the section *Damping-Off of Seedlings* on page 12.)

Verticillium Wilt

Sow and transplant in steamed or fumigated soil. Do not plant in fields where *Verticillium* wilt has been present unless the soil is treated with Vorlex 450 L/ha, according to manufacturer's directions. Good weed control is an important part of wilt control. A higher incidence of wilt may occur following peppers, tomatoes, eggplant, potatoes, strawberries and raspberries.

Phomopsis Blight

Avoid planting in infested fields for 3 years.

TABLE 5–25.
Eggplant Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest
Flea Beetles				
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.1 kg	2
		Thiodan 4 EC	1.5 L	2
		Thionex 400 EC	1.5 L	2
carbaryl	carbamate	Sevin XLR Plus	1.25 L	2
Aphids				
endosulfan[1]	chlorinated cyclodiene	Thiodan 50 WP	1.0–2.25 kg	2
		Thiodan 4 EC	1.5–2.75 L	2
		Thionex 400 EC	1.5–2.5 L	2
Tarnished Plant Bug				
dimethoate	organophosphate	Cygon 480 E	0.5–0.7 L	7
		Lagon 480 E	0.5–0.7 L	7
Colorado Potato Beetle				
carbaryl	carbamate	Sevin XLR Li	1.25 L	2
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.0–2.25 kg	2
		Thiodan 4 EC	1.5–2.75 L	2
		Endosulfan 50 W	1.1–2.25 kg	2
		Thionex 400 EC	1.5–2.5 L	2

[1] The green peach aphid is resistant to these insecticides in some areas.

Insect Management

Flea Beetles

Spray plants just before field setting with one of the insecticides listed in Table 5–25, *Eggplant Insect Control Recommendations*, above. Repeat in the field if monitoring indicates a need.

Aphids

If monitoring indicates a need, spray with one of the insecticides listed in Table 5–25, above.

Tarnished Plant Bugs

Monitoring for tarnished plant bug should begin at the time of flowering. If necessary, apply one of the insecticides listed in Table 5–25, above.

For more information, consult the OMAFRA Factsheet *Tarnished Plant Bug Damage on Vegetable Crops in Ontario*, Order No. 98-025.

Colorado Potato Beetle

If monitoring indicates a need, spray with one of the insecticides listed in Table 5–25, above.

Note: The Colorado potato beetle is quite resistant to these insecticides in many areas. Do a dip test before spraying. See the OMAFRA Factsheet, *Colorado Potato Beetle Dip Test*, Order No. 92-028.

Nematode Control

See the section *Nematodes* on page 17 for nematode control recommendations.

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GARLIC

Cultivars

The recommended cultivars in Ontario are the Music strains.

Note: Cultivated garlic plants do not produce true seed. All garlic is propagated vegetatively. Two types of garlic are grown in Ontario and are described as either "hardneck" or "softneck." For seed sources, consult the Ontario Garlic Growers Association.

Seeding and Spacing

The optimum planting date is from September to late October with October 15 being ideal most years. To estimate the planting date, use the average date for the first fall frost for the area in which garlic is to be grown and begin planting on this date. See Table 4–1, *Average Frost-Free Period in Climatic Zones of Ontario*, on page 40.

Rate: 700–1,000 kg of cloves/ha.

Depth of Planting: Allow for 3–5 cm between the soil surface and the top of the clove.

Row Spacing: Row centres of 20 cm or more depending upon equipment available; 7–12 cm apart within the row. Use wider spacing in lighter, drought-prone soils.

Soils

Garlic can be grown on a wide range of soil types providing the soils are well-drained, deep and fertile. Soils with good organic matter content are preferred due to the increased moisture and nutrient holding capacity. Extremely heavy soil types should be avoided.

Soil pH should range from 6.0–7.5. Low pH soils such as 5.0–5.5 or less, will result in very poor yields and plant stands.

Fertilizer

Nitrogen

On mineral soils, a total of 110 kg/ha is required. Calcium nitrate or calcium ammonium nitrate are the preferred sources. Half of the nitrogen should be applied as soon as the garlic plants begin to grow in the spring. The rest of the nitrogen should be applied in 2–3 side-dresses at 3-week intervals.

Phosphate and Potash

To establish pH, phosphorus and potassium requirements, a soil test should be used. Soil pH, phosphorus and potassium levels should be amended prior to fall planting. Phosphorus and potassium requirements are similar to onions.

Irrigation

Garlic is shallow-rooted and sensitive to moisture stress. For most soil types, approximately 2.5 cm of water is required per week. On very dry sandy soils, as much as 5.0 cm is required weekly.

Disease Management

Penicillium or Green Mould Disease

Green mould disease, caused by the fungus *Penicillium*, attacks cloves that have been damaged prior to planting. Affected cloves may fail to emerge in the spring or may produce weak, stunted plants that soon die. Plant only clonal cultivars known to be vigorous under Ontario growing conditions. Avoid damaging the seed cloves, especially during the cracking procedure. Many mechanized cracking devices cause excessive amounts of clove damage. Crack the seed immediately before it is to be planted. The cracked cloves may be treated with one of the fungicides listed in Table 5–26, *Garlic Disease and Insect Control Recommendations*, on page 83.

White Rot

See the section *White Rot* on page 94 and Table 5–26 on page 83.

Basal Rot

See the section *Basal Rot* on page 94.

Insect Management

Aphids, Thrips and Onion Maggot

See Table 5–26 on page 83, for control recommendations. For further details, consult the OMAFRA Factsheets, *Garlic Production in Ontario*, Order No. 97-007 and *Onion Maggot Control*, Order No. 00-017.

TABLE 5–26.
Garlic Disease and Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Penicillium or Green Mould Disease					
iprodione	dicarboximide	Rovral 50 WP	4 g/L of water		Dip cloves into the Rovral suspension prior to planting.
White Rot					
dichloran	quinone	Botran 75 W	6.75–11.0 kg	spring planting	Apply 1–2 weeks prior to planting and work into top 4 cm of soil.
			36.0–44.0 kg	fall planting	
Aphids and Thrips					
malathion	organophosphate	Malathion 500 E	1.1–2.75 L	3	
cyhalothrin-lambda	pyrethroid	Matador 120 EC	188 mL	14	Thrips only. Do not use more than 3 times per season. Minimum period for re-entry is 24 hours.
Onion Maggot					
chlorpyrifos	organophosphate	Lorsban 4E	3.5 L in 1,000 L of water	50	Apply as a drench over the row on newly emerged plants (in the spring).
		Pyrinex 480 EC	3.5 L in 1,000 L of water	50	

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HERBS

In general, herbs do best in full sunlight (chervil requires partial shade), in a protected location. They are best suited to well-drained, sandy loam soils that are slightly acidic and fertile. (Thyme prefers calcareous soils). Excessive fertility can reduce essential oils and fragrances in the leaf tissue of actively growing herbs.

Propagation

Methods of propagation vary dramatically. Most suppliers need available greenhouse and outdoor bed space. Year-round production may require cell trays and scheduled seeding. Each herb type may require specialized treatment for germination rate and seedling vigour. The method of propagation may vary depending on whether the supplier is offering bunches, custom orders or trays of live plants. It is essential to procure proper strains of certain herbs such as French tarragon. Purchase stock only from sources using marketable strains.

Overwintering Perennial Herbs

Straw mulching (wheat preferred) may be used to protect roots during the dormant season for perennials.

Fertility and Irrigation

Soils should be moderately fertile. A regular soil test should form the basis of any fertility program as well as regular incorporation of organic matter. Excessive use of nitrogen will produce weakly flavoured leaf and stem tissue. Herbs are generally more drought-tolerant than most vegetable crops. Water only when signs of wilt are evident. Mint may require irrigation at key times during production. Check with a crop specialist for specific recommendations.

Field Spacing

Space needs can vary considerably between the herbs. In-row spacing can vary from 20 cm for anise, parsley or sweet marjoram to 75 cm for coriander, dill, fennel and rosemary. Between-row spacing can vary from 90–120 cm depending on cultivation practices.

Disease and Insect Management

In both field and greenhouse, insects and diseases (such as mildew in rosemary or *Septoria* leaf blight, bacterial blight and clover worm in parsley) can affect many herbs. Various leaf-feeding caterpillars and aphids can be found on many species. Consult a crop specialist for management recommendations. Regular scouting activity can detect an outbreak of a certain pest before a serious infestation results.

TABLE 5–27.
Herb Type, Propagation, Parts Harvested/Sold

Herbs	Propagation	Leaves		Whole Shoot		Ripe, Dry Fruit	Flowers
		Fresh	Dried	Fresh	Dried		
ANNUALS							
Anise	S[1]	X				X	
Borage	S[1]	X	X			X	X
Caraway	S					X	
Chervil	S[1]	X	X	X	X		
Coriander	S[1]	X	X			X	
Dill	S[1]	X	X	X		X	
Fennel	S[1]	X	X	X	X	X	
Parsley[2]	S[1]	X	X				
Sweet basil	S[3]			X	X		
Sweet marjoram	S[3]				X		
Summer savory	S				X		
PERENNIALS							
Chives (bulb)	C, R, S[3]	X	X				
Lavender	C, R, S[4]						X
Lemon verbena	C, R	X	X				
Mint	C, R	X	X	X	X		
Oregano	C, R, S[3]				X		
Rosemary (non-hardy)	C, R, S[4]	X	X				X
Sage	C, R, S[3]	X	X	X	X		
Tarragon	C, R				X		
Thyme	C, R, S[3]				X		

C = cutting; S = seed; R = root division

[1] Direct seeding is best for field production.
[2] See the section *Lettuce, Endive & Parsley* on page 85.
[3] Direct seeding or transplants (plugs) are best for field production.
[4] Use transplant plugs for field production.

Competition Control and Mulching

A variety of methods of weed control are practised in herb plantings. Cultivation is perhaps the most useful tool. Mulches can help but may be costly. Consult a crop specialist regarding herbicide registrations in various herb crops as well as Chapter 6, *Weed Management for Vegetables* on page 141. Plastic mulch in combination with drip irrigation may be useful in some situations.

Harvesting for Fresh Market and Dry Market

If practical, harvest in early morning after the dew has dried from the crop and before the sun dissipates the essential oils; leaves should be clea. and free of dust and soil. Do not completely strip the stems of the entire leaf crop, as remaining leaves are necessary to keep the plants growing. All varieties listed are suitable for the dry market as well.

HERBS

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Borage	S[1]	X	X			X	X
Caraway	S					X	
Chervil	S[1]	X	X	X	X		
Coriander	S[1]	X	X			X	
Dill	S[1]	X	X	X		X	
Fennel	S[1]	X	X	X	X	X	
Parsley[2]	S[1]	X	X				
Sweet basil	S[3]			X	X		
Sweet marjoram	S[3]				X		
Summer savory	S				X		
PERENNIALS							
Chives (bulb)	C, R, S[3]	X	X				
Lavender	C, R, S[4]						X
Lemon verbena	C, R	X	X				
Mint	C, R	X	X	X	X		
Oregano	C, R, S[3]				X		
Rosemary (non-hardy)	C, R, S[4]	X	X				X
Sage	C, R, S[3]	X	X	X	X		
Tarragon	C, R				X		
Thyme	C, R, S[3]				X		

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LETTUCE, ENDIVE & PARSLEY

Cultivars

The varieties listed in Table 5–28, *Lettuce Cultivars*, right, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. In some cases, other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under Ontario growing conditions. Varieties of crops change frequently; check with a range of seed company representatives for additional recommendations and variety descriptions.

TABLE 5–28.
Lettuce Cultivars

For endive and parsley cultivars, see available seed catalogues for suggested varieties.

Crisphead	Boston (Bibb) and Butterhead
Transplants:	Buttercrunch
Ithaca	Summer Bibb
Seeded:	Dark Green Boston
Ithaca (early, mid, late)	Citation
Summertime	Sangria
Leaf	**Cos Or Romaine**
Early Spring	Paris Island Cos
Grand Rapids Forcing	Green Towers
New Red Fire	Bakito (red)
Royal Green	
Two Star	

Temperature

Lettuce is a cool-weather crop and grows best at temperatures between 16°C–18°C. Production is limited on mineral soils to the transplanted early crop and the seed-sown late crop. On muck soils, in cooler areas such as Bradford, lettuce may be produced throughout the growing season.

Properly hardened transplants, when set in the field in the early spring, can tolerate temperatures as low as –7°C. For the late crop on both muck and mineral soils, seeding time is important. If plants are immature when the first frost occurs, they will recover. Wrapper leaves on mature heads are very susceptible to frost and can only be marketed at a lower grade.

Germination occurs even at 4°C. At very high soil temperatures (27°C or above), germination is delayed.

Seed Treatment

See the section *Chemical Seed Treatment* on page 11.

Planting

Transplants

Start transplants in the greenhouse about 4 weeks before they will be planted in the field. Grow transplants in flats or plug trays using pasteurized soil or a soilless greenhouse mix. Sow 1 seed per cell. Even watering and fertilization is critical in plug transplant production. Harden plants and thoroughly soak soil with starter solution (20-20-20) before transplanting in the field.

Direct-Seeding

Sow seed in spring as soon as soil is ready at a rate of 1–2 kg/ha. Use coated or pelleted seed with a precision seeder to ensure a more uniform stand and germination, reduced thinning costs and higher percentages of cut at harvest time.

Spacing

Leaf and butterhead cultivars:	20–30 cm apart in rows about 30 cm apart
Crisphead lettuce:	30–35 cm apart in rows about 40 cm apart
Parsley:	10–15 cm apart in rows about 30–40 cm apart
Endive:	Depending on the variety, endive can be planted similarly to crisphead lettuce.

Thinning

Thin when 2 or 3 leaves have formed.

Fertilizer

Nitrogen

On mineral soils, apply up to 110 kg N/ha; on muck soils, apply up to 120 kg N/ha. If manure is applied or legume sod is plowed down, reduce the nitrogen application. (See Table 3–10 and Table 3–11 on page 28 and page 29.)

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 3–5, Table 3–6 and Table 3–7 on page 24 and page 25.)

Application

On mineral soils, broadcast 55 kg N/ha before planting and work in. Side-dress with an additional 55 kg N/ha 3 weeks after transplanting or after thinning the seeded crop. On muck soils, apply all the nitrogen as a preplant broadcast application. Apply up to 120 kg N/ha for early lettuce and up to 100 kg N/ha for mid-season or late plantings.

TABLE 5–29.
Lettuce, Endive and Parsley Disease Control Recommendations

Common Name	Group	Trade Name	Rate	Days to Harvest	Notes
Damping-Off and *Pythium* Stunt					
metalaxyl	acylamine	Ridomil 2G	25 kg/ha 115 g/100 m row		Apply product evenly with seed in seed furrow.
***Botrytis* (Gray Mould)**					
Greenhouse-grown seedlings					
ferbam	dithiocarbamate	Ferbam WDG	2 kg/1,000 L water		Spray 76% solution to wet plants only.
		Ferbam Dust	1–2 kg/100 m^2 of bed		Dust before first transplanting and once or twice later at 10-day intervals.
Field application					
iprodione	dicarboximide	Rovral WP	1.5 kg/ha	4	Apply a maximum of 4 applications starting just after thinning at 7-day intervals.
Downy Mildew					
zineb	dithiocarbamate	Zineb 80 W	2.25–2.75 kg/ha	10	Lettuce only.
metalaxyl/ mancozeb	acylamine & dithiocarbamate	Ridomil Gold MZ 68 WP	2.5 kg/ha	14	Lettuce only. Do not apply more than 3 times per season.
fosetyl-al	phosphonate	Aliette 80 WDG	2.8 kg/ha	7	Lettuce only. Minimum period for re-entry is 12 hours.
		Aliette 80 WP	2.8 kg/ha	7	Lettuce only. Minimum period for re-entry is 12 hours.
***Sclerotinia* White Mould (Drop)**					
dichloran	quinone	Botran 75 W	2.3–3.75 kg/ha	14	Lettuce only.
vinclozolin[1]	dicarboximide	Ronilan EG	1.1 kg/ha	28	Lettuce only. Minimum period for re-entry is 12 hours.

[1] Apply 1–2 days after thinning on seeded crop or 5–7 days after transplanting. Second and third applications may be made at 10-day intervals. Note that a 15-metre buffer zone must be maintained between sprayed areas and aquatic systems such as ponds and ditches.

Micronutrients

Copper

Copper deficiency may show up on acid peat and muck soils. Copper may be mixed with the fertilizer and applied at 14–29 kg copper/ha on new muck. Subsequent applications may be made every 2 or 3 years at about one-third the rate recommended for new muck. Consult the section *Copper* on page 27 and Table 3–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 26.

Manganese

Deficient lettuce shows marked yellowing between the veins, which remain dark green. Manganese deficiency usually shows up on slightly acid or alkaline muck, peat and dark-coloured sandy soils. Foliar applications, starting after thinning or transplanting, with manganese sulfate at rates supplying 1.0–2.0 kg manganese/ha in 3,000 L of water, are recommended where manganese deficiency has been a problem. Soil application is not recommended for manganese because of the large amounts required.

Calcium

Under hot, dry conditions, lettuce may benefit from calcium to prevent tipburn or blackheart symptoms. Consult the section *Calcium* on page 26 and Table 3–8 on page 26.

Disease Management

Damping-Off and Pythium Stunt

Steam or fumigate soil for growing transplants or use a soilless mix. (See the section *Damping-Off of Seedlings* on page 12.)

For direct, field-seeded crops follow the recommendation in Table 5–29, *Lettuce, Endive and Parsley Disease Control Recommendations*, above.

Botrytis (Gray Mould)

This common fungal disease often affects tissues damaged by other diseases or insects. Water-soaked lesions followed by a gray mould on lower leaves is characteristic. Follow the recommendations in Table 5–29, above, and ensure a proper nutrient balance and carefully timed irrigations that do not increase wetness periods.

Rhizoctonia Bottom Rot

This common, soil-borne fungus often causes a bottom rot near maturity, when leaves are touching the soil. Rust-coloured lesions followed by secondary rots are typical symptoms. Good drainage and growing on raised beds may be helpful.

Downy Mildew

Regular and consistent monitoring and the use of disease forecasting systems help to better manage this disease. Downy mildew can be a problem in seedling greenhouses and late lettuce crops. The fungicides listed in Table 5–29, *Lettuce, Endive and Parsley Disease Control Recommendations,* on page 86, are recommended.

Sclerotinia White Mould (Drop)

This disease affects many crops, including lettuce, carrots, beans and celery. Rotate with onions, beets or spinach for 2–3 years. Removal of crop refuse will help control the disease. Use row and plant spacings to encourage good air movement or plant on raised beds. Spray after thinning, as detailed in Table 5–29 on page 86, with a directed spray to lower portion of plants.

Corky Root Rot

This problem is caused by a difficult-to-detect bacteria or excess nitrogen. Allow sufficient time between lettuce crops for the plant residues to decompose completely. Avoid applying excessive amounts of nitrogen, especially urea. Most Boston types have good resistance.

Aster Yellows

The symptoms of aster yellows on lettuce and endive are bright yellowing and twisting of leaves, poor head formation on crisphead types, often followed by secondary bacterial rots. See the section *Aster Leafhoppers,* right, for control recommendations.

Lettuce Mosaic Virus

Mosaic-indexed or mosaic-tested seed is available from most sources. This seed is produced in special areas where it is carefully checked to ensure that it is virtually free from seed-borne mosaic. Control aphids, which spread the disease from infected lettuce plants and weeds such as groundsel, shepherd's purse and lamb's-quarters.

Bacterial Wilt (Dry Leaf Spot)

This disease caused by *Xanthomonas* bacteria has become more prevalent in recent years. The disease is characterized by water-soaked, wedge-shaped spots along the leaf margins that may also become olive-coloured. Excessive nitrogen or overhead irrigation may increase disease levels. All greenhouse areas used for transplant production must be disinfected.

Parsley Leafspot (Septoria)

This fungal disease, which is primarily seedborne, causes greyish-brown spots with cinnamon-brown margins on leaves and petioles. Crop rotation, removal and/or deep plowing of crop residues, hot water seed treatment and careful management of overhead irrigation may reduce diseases levels. Seed that is more than 2 years old will have less disease also.

Insect Management

Cutworms

Follow the recommendations listed in Table 5–30, *Lettuce, Endive and Parsley Insect Control Recommendations,* on page 88. Also see the section *Cutworms* on page 16 for additional cutworm management recommendations.

Aster Leafhoppers

Control leafhoppers, because they spread aster yellows. Leafhoppers can be monitored with a sticky trap (if checked daily) or with a sweep net to help determine when and if sprays are required. Without daily monitoring, there is no way to predict whether scheduled spraying with insecticides will provide any control. Also control weeds in headlands and ditchbanks and control aster leafhoppers on adjacent carrots and celery. After harvest, disk down unmarketable heads immediately. To delay pesticide resistance, alternate the groups of insecticides listed.

The Aster Yellows Index (AYI)

Monitor aster leafhoppers with a sweep net. Multiply the number of aster leafhoppers captured in 100 sweeps by the percentage of leafhoppers carrying aster yellows in your area. (Contact a crop specialist.)

Treat when the AYI equals 20–25 for head lettuce and 30–35 for romaine and celery, for example:

$$\frac{\text{\# leafhoppers}}{\text{100 sweeps}} \times \text{\% infectivity} = 20\text{–}25$$

For more information, consult the OMAFRA Factsheet, *The Aster Leafhopper and Aster Yellows,* Order No. 98-057.

If monitoring indicates a need, spray with one of the pesticides recommended in Table 5–30, *Lettuce, Endive and Parsley Insect Control Recommendations,* on page 88.

Treatment to Soil at Seeding Time

Two soil treatments at seeding time are also labeled:

1. Apply phorate (organophosphate group) (Thimet 15G) (lettuce only) at 7.25 kg/ha in the fertilizer band on one or both sides of the row at seeding time, or when transplants are set in the field. See label for directions and cautions.

TABLE 5–30.
Lettuce, Endive and Parsley Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Cutworms					
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	3	Head lettuce only. Dark-sided and white cutworms only. See also Table 2–2, *Cutworm Treatments*, on page 16. Do not apply more than 3 times per season.
Aster Leafhoppers					
cypermethrin	pyrethroid	Ripcord 400 EC	125 mL	14	Lettuce only.
		Cymbush 250 EC	200 mL	14	
parathion	organophosphate	Parathion 960 EC	225–375 mL	7	Head lettuce. Minimum period for re-entry is 7 days.
				21	Leaf lettuce. Minimum period for re-entry is 7 days.
malathion	organophosphate	Malathion 500 E	1.5–2.75 L	3	Head lettuce.
				14	Leaf lettuce.
carbaryl	carbamate	Sevin XLR Li	1.25–2.5 L	5	Head lettuce.
				21	Leaf lettuce, endive, parsley.
Aphids					
dimethoate	organophosphate	Cygon 480 E	0.7 L	7	Lettuce only.
		Lagon 480 E	0.7 L	7	
pirimicarb	carbamate	Pirimor DF	300–500 g	7	Lettuce only.
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	2 L	14	Head lettuce only. Do not apply more than 3 times per season.
		Endosulfan 50W	1.75 kg	14	
		Thionex 400 EC	2 L	14	
parathion	organophosphate	Parathion 960 E	225–375 mL	7	Head lettuce. Minimum period for re-entry is 7 days. The green peach aphid may be becoming resistant to this insecticide.
				21	Leaf lettuce. Minimum period for re-entry is 7 days. The green peach aphid may be becoming resistant to this insecticide.
methamidophos	organophosphate	Monitor 480 EC	1.1–2.25 L	14	Head lettuce only. Minimum period for re-entry is 48 hours.
naled	organophosphate	Dibrom EC	1.1–1.65 L	4	Lettuce/endive only. Control of aphids with naled and diazinon has been inconsistent in many areas.
diazinon	organophosphate	DZN 600 EW	0.915 L	10	Lettuce. Control of aphids with naled and diazinon has been inconsistent in many areas.
				14	Parsley. Control of aphids with naled and diazinon has been inconsistent in many areas.
		Diazinon 500 E	1.1 L	10	Lettuce only. Control of aphids with naled and diazinon has been inconsistent in many areas.
acephate	organophosphate	Orthene SP	0.75–1.1 kg	7	Head lettuce only. Do not apply more than 4 times per season.
imidacloprid	chloronicotinyl	Admire 240 F	10.2 mL/ 1,000 plants	21	Transplant tray plug drench. **Do not follow a transplant plug application with a field drench or foliar application.** Minimum period for re-entry is 24 hours.
		Admire 240 F	0.65 L	21	Soil application – field drench. See label for conversion chart for linear application for common row spacings. Apply to plants as a drench after transplanting using 2,000 L water per ha. Only one drench per field per season is permitted. Minimum period for re-entry is 24 hours.
		Admire 240 F	200 mL	7	Foliar application. One application per crop and a maximum of 2 foliar applications per field per season is permitted. **Do not make Admire foliar application following a plug treatment or soil drench application.** Minimum period for re-entry is 24 hours.

TABLE 5–30.
Lettuce, Endive and Parsley Insect Control Recommendations (Continued)

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Cabbage Looper					
bacillus thuringiensis	microbial	Dipel 2XDF	275–550 g	0	Lettuce/parsley only; 275 g rate max. for parsley.
		Thuricide HPC	2.0–4.25 L	0	Lettuce only.
methomyl	carbamate	Lannate SP	0.51–1.0 kg	7	Head lettuce only.
methamidophos	organophosphate	Monitor 480 EC	1.25–2.25 L	14	Head lettuce only. Minimum period for re-entry is 48 hours.
naled	organophosphate	Dibrom EC	1.1–1.65 L	4	Lettuce/endive only.
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	2 L	14	Head lettuce only. Do not apply more than 3 times per season.
		Endosulfan 50 W	1.75 kg	14	
		Thionex 400 EC	2 L	14	
acephate	organophosphate	Orthene SP	0.75–1.1 kg	7	Head lettuce only. Do not apply more than 4 times per season.
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	3	Head lettuce only. Do not apply more than 3 times per season. Minimum period for re-entry is 24 hours.
Tarnished Plant Bug					
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	2 L	14	Head lettuce only.
		Thionex 400 EC	2 L	14	
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	3	Head lettuce only. Do not apply more than 3 times per season. Minimum period for re-entry is 24 hours.

2. Apply disulfoton (organophosphate group) (Di-Syston 15 G) (lettuce only) at 40–75 g/100 m of row at seeding time, in a band on each side of the row. See cautions on the label. Do not use on transplanted lettuce. Use the higher rate on heavy and organic soils.

Aphids

Monitoring for aphids can help determine when and if sprays are required. Check 50–100 plants randomly in the field and measure the percentage of plants infested with aphids. Also note the average number of aphids per plant. Consult the OMAFRA Factsheet *Aphids Infesting Lettuce and Celery in Ontario,* Order No. 98-079.

Spray with one of the pesticides recommended in Table 5–30, *Lettuce, Endive and Parsley Insect Control Recommendations,* on page 88.

Cabbage Looper

This is not a common problem in Ontario. If monitoring indicates a need, apply one of the insecticides recommended in Table 5–30, *Lettuce, Endive and Parsley Insect Control Recommendations,* on page 88.

Tarnished Plant Bug

Romaine lettuce is particularly susceptible. If monitoring indicates a need, apply one of the insecticides recommended in Table 5–30 on page 88.

For more information, consult the OMAFRA Factsheet *Tarnished Plant Bug Damage on Vegetable Crops in Ontario,* Order No. 98-025.

Note: The booklet *IPM for Onions, Carrots, Celery and Lettuce in Ontario,* Order No. 700, provides a comprehensive guide to IPM on lettuce.

Nematode Control

See the section *Nematodes* on page 17 for nematode control recommendations.

Visit the vegetable page on the OMAFRA Web site at http://www.gov.on.ca/OMAFRA/english/crops/hort/vegetable.html

OKRA

Cultivars

The varieties listed in Table 5–31, *Okra Cultivars*, right, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. In some cases, other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under Ontario growing conditions. Varieties of crops change frequently; check with a range of seed company representatives for additional recommendations and variety descriptions.

Planting and Spacing

Okra is a very-warm-season crop and is best suited to southwestern Ontario and areas along Lake Erie's north shore. The crop is best established by transplants that have 3 to 4 true leaves. Consult the OMAFRA Factsheet, *Growing Vegetable Transplants in Plug Trays*, Order No. 96-023, for more information. Okra grows very quickly once seeded and therefore should not be planted too soon. Set transplants into the field once all chance of frost has passed.

Okra can be transplanted into black plastic mulch with or without drip irrigation tape. The plastic helps warm the soil and provides weed control.

Recommended field spacings suggest 90–120-cm rows with about 30–45 cm between plants. Okra grows best on lighter sandy and sandy loam soils rather than on heavy clay soils.

Fertilizer

Ontario recommendations for nitrogen, potassium & phosphorus of okra are not established, however all fertilizer applications should be based on a soil test.

Nitrogen is recommended prior to planting at rates of 30–50 kg N/ha, followed by a side-dressing of 20–50 kg N/ha when the plants are 20–25 cm high. An additional application of about 20 kg N/ha after first fruit set is suggested in most production areas. If plastic mulches are used, however, side-dressing becomes more difficult. It is very important not to apply too much nitrogen to okra, as fruit quality and yield will be reduced.

TABLE 5–31.
Okra Cultivars

Annie Oakley II
Cajun Delight
Clemson Spineless 80
North & South
Green Best

Disease Management

Few, if any, diseases affect okra in Ontario presently, however, if crops are not rotated, okra is susceptible to *Verticillium* and *Fusarium* fungi. In addition, root-knot nematodes are known to attack okra if populations are high.

Insect Management

Very few insects attack okra in Ontario, however, aphids and thrips may be observed during hot, dry summers. No pest control products are labeled for okra in Ontario.

Weed Management

Weed management will depend upon cultivation and hand-weeding, as herbicides are unavailable for okra. Monitoring of weed populations and stale-seedbed preparation will help reduce weed problems. Planting into black plastic mulch will also provide weed control.

Harvesting and Storage

Okra is harvested over a long period. All mature pods should be removed as any left on the plant will reduce flowering and fruit set. Generally, pods are harvested when they are 6–9 cm long. Varieties may differ in their tenderness at different pod lengths. Harvesting will be necessary every day during hot weather and every second or third day during cooler weather.

Okra will not tolerate frost; damage will be visible on the pods as water-soaked, sunken areas.

Okra will store only for short periods at temperatures of 7°C–10°C and high relative humidity. The crop should be marketed within a week of harvest.

Visit the vegetable page on the OMAFRA Web site at
http://www.gov.on.ca/OMAFRA/english/crops/hort/vegetable.html

ONION & LEEK

Cultivars

The onion varieties listed in Table 5–32, *Onion Cultivars and Descriptions*, on page 92, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. In some cases, other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under Ontario growing conditions. Varieties of crops change frequently; check with a range of seed company representatives for additional recommendations and variety descriptions.

Consult seed company representatives for leek varieties currently recommended in Ontario

Seeding and Spacing

Seeding

Dry onions:	4–4.5 kg/ha
Bunching onions:	up to 7 kg/ha
Pickling onions:	35–45 kg/ha
Sets:	70–80 kg/ha

Spacing

Plant dry onions in rows 35–43 cm apart or 15 and 60 cm apart alternately, with 30–40 plants/m of row.

Plant Spanish transplants 10–12.5 cm apart in the row, in rows 35–43 cm apart or 15 and 60 cm apart alternately.

Seed processing (dicing) onions at a rate to achieve 60–80 onions/m or row.

Plant leeks 10–15 cm apart.

Irrigation

Onions have a shallow, limited root system and should be irrigated consistently up to and including the bulb formation stage. Do not permit the soil moisture to fall below 50%. The plants should receive 2.5 cm of water a week, either as rainfall or irrigation. Irrigation may not be necessary on deep muck soils. Maintain the water table at 85 cm below the soil surface on muck soils. Irrigation after bulb maturity may not be beneficial and may reduce yield and/or quality.

Fertilizer

Monoammonium Phosphate

On shallow muck soil or soils with a high proportion of mineral soil, use 200 kg/ha monoammonium phosphate (MAP), applied 5–7.5 cm below the seed. Reduce the broadcast fertilizer by 22 kg/ha nitrogen and 96 kg/ha phosphate.

Nitrogen

On muck soils, apply 90 kg/ha pre-plant with one side-dressing of 30 kg N/ha when plants are 8–10 cm high (if rainfall has been above normal or soil temperatures below normal). On mineral soils, apply up to 110 kg N/ha per season. Leeks require higher amounts of nitrogen than onions, normally around 200 kg N/ha, applied in three instalments: one pre-plant and two side-dressings. If manure is applied or legume sod is plowed down, reduce the nitrogen application. (See Table 3–10 and Table 3–11 on page 28 and page 29.)

Phosphorus and Potassium

Soil tests are required to determine phosphate and potash requirements. (See Table 3–5, Table 3–6 and Table 3–7 on page 24 and page 25.)

Micronutrients

Copper

Copper deficiency occurs on acid, peat and muck soils. Onion bulbs show poor-coloured skins. Copper may be mixed with the fertilizer and applied at 14–29 kg copper/ha on new muck. Subsequent applications may be made every 2 or 3 years at about one-third the rate recommended for new muck.

Manganese

Manganese deficiency shows up as a yellowing between the leaf veins. Foliar applications of manganese sulfate are recommended, starting when the plants are about 15 cm tall with 1.5–2.75 kg manganese sulfate/ha in 300 L water, repeated in 4–5 sprays 10 days apart. Use the low rate on small plants, increasing the rate as the season progresses. Soil application is not recommended for manganese because of the large amounts required.

Molybdenum

Molybdenum deficiency may occur when onions are grown on moderately acid to strongly acid muck soils. A seed treatment has proven beneficial. The treatment is accomplished by dissolving 15 grams of sodium molybdate in 45 mL of water. Spray this solution from an atomizer bottle on 2.3 kg seed spread thinly on a plastic sheet. Do not use excessive water as this can cause the chemical to penetrate the seed embryo and cause injury. Mix the seed thoroughly and let dry. Spraying plants with sodium molybdate at rates supplying 60 g of molybdenum in 300 L of water will also help avoid deficiency symptoms.

TABLE 5–32.
Onion Cultivars and Descriptions

Cultivar	Description
Cooking	
Early	
Advancer	Very early maturity, good bulb size, nice colour, short-term storage.
Corona	Early maturity, high yield potential, light colour, short-term storage.
Eskimo	Very early maturing, good neck finish, medium size bulbs, suitable for short-term storage only.
Frontier	Early maturing, average yields, small necks, medium-large bulbs, medium storage.
Norstar	Very early maturing, large size, high yield potential, short-term storage only.
Mid to Late Maturing	
Capable	Early maturing, high globe bulbs, yellow skin colour, suitable for long-term storage, good tolerance to pink root.
Copra	Very firm, very late maturity, high yielding, excellent scoring, excellent for long-term storage.
Fortress	Round globe, dark colour, good neck finish, longer storage potential, pink root tolerance.
Gazette	Large, firm bulbs, high globe shape, bronze skin, good storage.
Hamlet	Mid-season maturity, good yields, uniform bulbs, long storage, good colour, pink root tolerance.
Headliner	Mid-maturity, firm bulbs, copper colour, good scale retention and longer term storage.
Millennium	Large bulbs, light copper colour, pink root tolerant, good storage.
Paragon	Very firm, high yield potential, good bulb size, excellent quality, suitable for long-term storage.
Prince	Mid-season maturity, blocky globe bulb, nice colour, good yields, mid-to-long storage.
Quantum	Early to mid-maturity, good yields, globe shape, good colour and short-term storage.
Salem	High globe shape, large bulbs, dark copper colour, stores well.
Tamara	Globe shape, later than Prince, good yields and colour, long-term storage.
Tarmagon	Early maturing, very high yield potential, large globe size, quite firm, suitable for medium-long storage.
Tribute	Mid-season maturing, globe shape, above-average yields, stores well.
Uniglobe 100	Large firm bulbs with tight necks, high globe shape, good size, long-term storage.
Sets	
Ebenezer (White and Yellow)	White Ebenezer is used for very early, mild, green bunching onions. Yellow Ebenezer is a set-onion type for the production of cooking onions.
Jet Set	No description available here, consult seed catalogues.
Stuttgarter	No description available here, consult seed catalogues.
White Portugal	Used for green bunching and for pickling.
Bunching	
Ishikara	Stiff, upright tops, little to no bulbing, good spring or late summer crop.
Kincho	Late summer type, blue green leaves, skins well, long, white stems, uniform.
Parade	Dark green stalks, upright growth with no branching, excellent green-to-white ratio.
Southport White Globe	The main green bunching onion for early, mid, and late season.
Pickling (pearl type)	
Barletta	Used for pearl-onion processing.
Pompei	White, earlier than Barletta, used for pearl-onion processing.
Silver Queen	Used for pearl-onion processing.
White Portugal	Used for green bunching and for pickling.
Spanish	
Brahma	Large-bulbing, mid-season-maturing Spanish type, good resistance to bolting, high yield potential, good quality, light brown skin.
Regiment	Medium-large, round bulb with dark skin, some tolerance to pink root and *Fusarium*.
Vaquero	Late maturity, high percentage single centres, good firmness.
Vega	Globe-shaped with excellent size potential and moderate pink root resistance.
Viceroy	Mid-season maturity, good yield, nice colour, some storage potential, bolting tolerance.
Yula	Excellent fresh market Spanish, medium to early maturing.
Red	
Benny's Red	Red-skinned, attractive, matures slightly later, not for long storage.
Mars	Light red exterior and interior colour, uniform size and shape, high globe, short storage life, good yield.
Mercury	Red exterior, good interior colour, good size, globe shape, mid-season maturity.
Redwing	Dark red skin colour, large bulbs, good storage, bulbs become darker after harvest.
Ruby	Red-skinned, attractive, matures slightly later, short storage only.

TABLE 5–33.
Onion & Leek Disease Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Downy Mildew, *Botrytis* Leaf Blight, Purple Blotch					
zineb	dithiocarbamate	Zineb 80 W	2.25–3.25 kg	7	Onions only.
mancozeb	dithiocarbamate	Dithane M-45	2.25–3.25 kg	10	Labeled for dry onions only.
		Dithane DG	2.25–3.25 kg	10	
		Manzate DF	2.25–3.25 kg	10	
		Penncozeb 75 DF	2.25–3.25 kg	10	
iprodione	dicarboximide	Rovral[1]	0.75 kg	15	When tank-mixed with label rates of maneb or mancozeb. Onions only.
chlorothalonil	chloronitrile	Bravo 500 F	2.4–4.8 L	7	Dry bulb. Not for the control of onion downy mildew.
				14	Green bunching. Not for the control of onion downy mildew.
metalaxyl/ mancozeb	acylamine & dithiocarbamate	Ridomil Gold MZ 68 WP	2.5 kg	7	Onions only. For downy mildew only; apply before first outbreak of disease.
fosetyl-al	phosphonate	Aliette 80 WDG	2.8 kg	7	For downy mildew and purple blotch on onions only. Minimum period for re-entry is 12 hours.
		Aliette 80 WP	2.8 kg	7	

[1] Rovral when tank-mixed will control *Botrytis* leaf blight and downy mildew when applied on a preventative basis. This tank-mix combination will help reduce the chance of resistance to iprodione.

Zinc

Zinc deficiency in onions shows up as a stunting and marked twisting and bending of yellow striped foliage. It occurs mainly with shallow muck soils or where the calcareous subsoils are mixed with the muck. If zinc deficiency is a problem, spray the foliage with zinc sulfate at rates supplying 0.6 kg zinc per 1,000 L water.

Disease Management

Damping-Off and Root Rot

Treat seed with thiram (dithiocarbamate group) seed protectant. Use pasteurized soil or soilless mix and disinfect trays.

Downy Mildew, Botrytis Leaf Blight and Purple Blotch

Plant sets and mother bulbs as far as possible from onions being grown from seed. These diseases develop in humid weather or when rains and heavy dews occur frequently. Begin spraying when these conditions occur after early June in southwestern Ontario and after mid-June in the Bradford area. Then spray every 7–10 days with one of the fungicides recommended in Table 5–33, *Onion & Leek Disease Control Recommendations*, above; a spreader-sticker may be required if recommended by the manufacturer.

Disease forecasting models and crop monitoring can greatly improve disease management. Consult the OMAFRA Factsheet *Identification of Diseases and Disorders of Onion*, Order No. 95-063. These diseases can also be serious on leeks, however no fungicides are labeled for leeks currently.

Smut

1. Treat seed with carbathiin (oxathiin group) + thiram (dithiocarbamate group) (PRO-GRO) 60 grams to 2.3 kg of seed.

   Use of a methyl cellulose sticker helps the PRO-GRO remain on the seed and improves smut control. The sticker is available at no charge from the Muck Crops Research Station, Kettleby, Ontario (905) 775-3783. Thorough mixing of PRO-GRO with the sticker and the seed is essential for good control. Mix until no uncoated seeds can be found. Read label directions. Also see the section *Onion Maggot* on page 94.

2. **Furrow Granular Treatment:** For use especially when cyromazine (Governor) seed treatment is used for onion maggot control. Apply mancozeb (dithiocarbamate group) Dithane 75 DG 4.4–8.8 kg (100 days) in the furrow at seeding time (dry bulb onions only). Use the high rate only in fields with severe onion smut pressures. Do not plant onions the following year.

3. Steam pasteurize soil for growing Spanish onion transplants or use a commercial soilless mix.

Botrytis Neck Rot and Smudge

Be certain onions are mature before harvesting. Cure and dry onions properly. Artificial heat may be beneficial. Store under cool, dry conditions. White and Spanish-type onions are more susceptible to these diseases.

Basal Rot

This soil-borne *Fusarium* disease prefers warm soil temperatures and is more common in southwestern Ontario. Early symptoms include yellowing and tip dieback. As the disease progresses, the plant will collapse, the roots will decay and the basal plate will have a pinkish colour. Secondary rots often follow. Crop rotation and the use of disease-free transplants is recommended.

White Rot

Onion white rot disease is a serious threat to onion and leek production if present. The fungus survives as sclerotia in the soil for long periods. The hosts are within the onion family: onion, shallot, leek, garlic. Long-term rotation with carrots, lettuce, potatoes or other crops not related to the onion family is recommended. Rotations of 10–20 years may not reduce the population of white rot in heavily infested soil.

Flooding fields in the fall, winter or spring may reduce white rot. The longer the field is flooded, the more effective the treatment will be. Solarization (covering moist soil with clear plastics) can also reduce white rot in fields with a moderate infestation.

Sanitation is extremely important in preventing the spread of this disease. Wash down machinery after it has been used in an infested field. Avoid cultivation practices that can spread contaminated soil from one area to the rest of the field. Dispose of cull onions in a sanitary landfill or bury away from areas of onion production. Pallet boxes that have been used to hold contaminated soil or diseased onions may also be a source of disease and should be cleaned or destroyed.

Pink Root

This soil-borne disease rarely causes severe damage but may reduce bulb size or stunt growth especially in drier areas of the field. The roots turn pink or maroon when infected. Long rotations, good nutrition and irrigation may be helpful.

Leek Rust

Rust is a fungal disease that occasionally attacks leeks. Rust-coloured spores on the upper and lower leaf surfaces are characteristic symptoms.

Bacterial Diseases

There are at least three different diseases of onions caused by bacteria; these are soft rot, slippery skin and sour skin. The bacteria that cause slippery skin and sour skin can enter the onion through wounds on the leaves and when heavy irrigation or rainfall results in water standing in the leaf axils and neck. Any of these bacteria can enter the bulb when the leaves wither after windrowing or through injuries that occur at harvest. Soft rot often occurs when bulbs are damaged by the onion maggot or by other bulb diseases. To reduce bacterial diseases, control the onion maggot, do not over-irrigate and avoid damaging the onions at harvest. Let the onions mature properly before harvest, then cure and dry them rapidly.

Consult the OMAFRA Factsheet *Identification of Diseases and Disorders of Onion,* Order No. 95-063.

Insect Management

Onion Maggot

Dry Onion Grown from Seed

See Table 5–34, *Onion & Leek Insect Control Recommendations,* on page 95, for control recommendations for onion maggot in dry onion grown from seed.

Sprays for Onion Maggot Flies

Seed treatment or proper placement of granular insecticides at the correct rate is the key to onion maggot control. If difficulties are encountered with the granular application, sprays to kill the flies may reduce their numbers, however, evidence suggests that sprays for flies do little to reduce overall damage from maggots in cooking onions and Spanish onions. If foliar sprays are chosen, use one of the materials listed in Table 5–34 on page 95, in sufficient water to obtain good coverage if monitoring indicates flight activity is increasing. To limit the development of resistance, the insecticides from the pyrethroid group must be used alternately with insecticides from the organophosphate group.

Other Onions

Dutch Sets: Make sure insecticide is distributed evenly over the entire width of the row. Apply soil insecticide treatment and sprays as described in Table 5–34 on page 95.

Pickling Onions from Seed: Apply ethion or chlorpyrifos and sprays as described in Table 5–34 on page 95.

Green Bunching Onions from Seed: Use seed treatment or apply ethion and sprays as described in Table 5–34 on page 95.

Green Bunching Onions from Sets: Apply sprays as described in Table 5–34 on page 95.

Spanish Onions from Transplants: Special application equipment is required to distribute insecticide uniformly

TABLE 5–34.
Onion & Leek Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Onion Maggot					
Seed treatment for dry onions and green onions grown from seed					
cyromazine	triazine	Governor 75 WP	66.7 g/kg of seed	100	Use on imported onion seed only; treated seed may only be planted on muck soils and may not be planted in the same field in successive years.
Soil insecticide (furrow granular) treatment Apply granular formulation in furrow with seed. Amounts given are for 1 ha. Adjust the dosage if row spacing or planting methods differ.					
chlorpyrifos[1, 2]	organophosphate	Lorsban 15 G[3]	8–16 kg	109	Dry onions only.
				97	Pickling onions only.
		Pyrifos 15 G[3]	8–16 kg	109	Dry onions only.
				97	Pickling onions only.
ethion-thiram[4]	organophosphate & dithiocarbamate	Ethion 5 & Thiram 7.5 G	33–83 kg		On muck soils depending on onion type. Consult the label.
			23–45 kg		On mineral soils depending on onion type. Consult the label.
Sprays for onion maggot flies					
cypermethrin	pyrethroid	Ripcord 400 EC	175 mL	3	Onions only.
		Cymbush 250 EC	280 mL	3	Onions only.
diazinon	organophosphate	Diazinon 50 WP	1.1 kg	10	Onions only.
		Diazinon 500 EC	1.1 L	10	Onions only.
		DZN 600 EW	0.915 L	10	Onions only.
parathion	organophosphate	Parathion 960 EC	225–375 mL	21	Onions only. Minimum period for re-entry is 7 days.
naled	organophosphate	Dibrom EC	0.55 L	4	Onions only.
Thrips					
cypermethrin	pyrethroid	Cymbush 250 EC	280 mL	3	Onions only. Do not apply more than 3 times per season.
naled	organophosphate	Dibrom EC	0.55 L	4	Onions only.
deltamethrin	pyrethroid	Decis 5.0 EC	200 mL	5	Do not apply more than once per season.
cyhalothrin-lambda	pyrethroid	Matador 120 EC	188 mL	14	Do not apply more than 3 times per season. Minimum period for re-entry is 24 hours.

[1] Use with carbathiin + thiram-treated seed.
[2] Use only on dry onions and pickling onions. For precision seeders having a seed furrow width of 5 cm or less, use Lorsban 15 G or Pyrifos 15 G at a rate of 64 g/100 m of double row. Based on a standard 40-cm row spacing, this is equivalent to 16 kg Lorsban 15 G/ha. Consult the label.
[3] Resistance to these insecticides has been observed in Ontario muck soils.
[4] Ethion-thiram is labeled for dry onions from seed or sets, Dutch sets from seed, pickling onions, green onions and Spanish onions.

within the furrow. Apply soil insecticide treatment and sprays as described in Table 5–34, above.

Cooking Onions from Sets: Apply soil insecticide and sprays as described in Table 5–34, above.

Onions left in the field after harvest are a major source of overwintering onion maggot. This is especially true following early harvest of Dutch sets and pickling onions. Prevent all regrowth. Remove, where possible, or plow under immediately after harvest. Also, rogue out all volunteer onions early in the season. Consult the OMAFRA Factsheet *Onion Maggot Control*, Order No. 00-017.

Thrips

Monitoring greatly improves the management of thrips on onions. First, estimate the average leaf stage of the crop, then check at least 50–100 plants randomly in the field and record the average number of thrips per plant. Divide by the leaf stage to give the number of thrips per leaf. Thresholds for green onions and Spanish onions (1 thrip/leaf) are lower than those for cooking onions and leeks (3 thrips/leaf). Cypermethrin, diazinon and parathion, recommended as sprays for onion maggot flies, will also control thrips (see Table 5–34, above). Evidence suggests that thrips may develop high levels of resistance in onion fields where repeated use of insecticides occur. Hot, dry weather favours thrips infestations. Water volume, coverage and timing are critical. Consult

the OMAFRA Factsheet, *Thrips on Onions and Cabbage*, Order No. 99-027.

Cutworms

Cutworms are an occasional pest of onions in Ontario. If monitoring indicates a problem, refer to the section *Cutworms* on page 16 for cutworm management recommendations.

Note: The booklet *IPM For Onions, Carrots, Celery and Lettuce in Ontario*, Order No. 700, provides a comprehensive guide to IPM for onions.

Nematode Control

See the section *Nematodes* on page 17 for nematode control recommendations.

Sprout Inhibition

The use of maleic hydrazide (Royal MH 60) sprays will improve the storage life and quality of onions by inhibiting sprouting in storage. Short-storage-life cultivars do not benefit from maleic hydrazide sprays. Apply at a rate of 3.75 kg in a minimum of 300 L of water/ha for ground equipment or a minimum of 100 L of water for aerial equipment. To obtain maximum benefit, spray when about 50% of the onion tops have fallen and each plant has 5–8 green leaves. This will occur about 10–14 days before harvest. Earlier application may result in spongy, hollow-necked bulbs.

Consult the OMAFRA Factsheet, *Leek Production*, Order No. 91-004, for more information on leeks.

Visit the vegetable page on the OMAFRA Web site at http://www.gov.on.ca/OMAFRA/english/crops/hort/vegetable.html

PARSNIP

Cultivars

The varieties listed in Table 5–35, *Parsnip Cultivars and Descriptions*, right, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. In some cases, other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under Ontario growing conditions. Varieties of crops change frequently; check with a range of seed company representatives for additional recommendations and variety descriptions.

TABLE 5–35.
Parsnip Cultivars and Descriptions

Cultivar	Description
All-America	Early cultivar with smooth wedge-shaped white roots, tall, strong tops.
Andover	Gradually tapered root, superior storing ability, vigorous tops, resistant to *Phoma* canker. Seed supplies may be limited.
Arrow	No description available here, consult seed catalogues.
Harris Model	Smooth, slim, tapered root, good appearance.
Hollow Crown Improved	Wedge-shaped, smooth white roots with fine texture, short tops.
Javelin	No description available here, consult seed catalogues.

Seeding and Spacing

Parsnips are a long-season crop (100–130 days to maturity), so the seed must be sown as early as possible. Always use seed produced the preceding year. The seed is slow to germinate, especially in dry, cool soils. Poor stands occur if the soil surface becomes baked or crusted before the seedlings emerge.

Rate: 3–5.5 kg /ha
Depth: 6–20 mm
Row Spacing: 45–75 cm depending on machinery used in cultivation
Thinning: Thin seedlings 3–6 cm in the row. On muck soils, adjust seeders to ensure a stand of 16–33 plants/metre of row.

Soil

Parsnips require deep, loose, fertile soils, preferably a well-drained, warm sandy loam. Well-drained muck soils are also suitable. The desired pH is about 6.5.

Fertilizer

Fertilizer requirements are the same as for carrots. (See *Carrots* on page 66.) For more detail, consult the OMAFRA Factsheet, *Commercial Parsnip Production in Ontario*, Order No. 81-056.

Disease Management

Itersonilia Canker and Leaf Spot

High ridging to cover the shoulder of the roots is helpful. The cultivar Andover has resistance to *Itersonilia* and *Phoma* canker.

Phoma Canker and Leaf Spot

Andover, Hollow Crown Improved and All-America are tolerant cultivars. They can be grown instead of Harris Model, the most susceptible cultivar, and harvested before maximum root and shoulder development. Rotate with other crops. Removal of crop refuse will help to control the disease. See Table 5–36, *Parsnip Disease and Insect Control Recommendations*, below. For more detail, consult the OMAFRA Factsheet, *Phoma Canker of Parsnip*, Order No. 87-041.

Insect Management

Carrot Rust Fly

See the section *Carrot Rust Fly* on page 69. If monitoring indicates a need, apply as directed in Table 5–36, below.

Caution: Some individuals may be sensitive to the natural chemicals found in parsnip foliage. The level of these substances increases if parsnips are diseased. Using rubber gloves when handling parsnip foliage and leg protection when walking in the field will prevent the development of skin rashes.

Root-Knot Nematode Control

See the section *Nematodes* on page 17.

TABLE 5–36.
Parsnip Disease and Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest
Phoma Canker and Leaf Spot				
chlorothalonil	chloronitrile	Bravo 500 F	2.8 L	7
Carrot Rust Fly				
diazinon	organophosphate	Diazinon 500 EC	1.1 L	10
		Diazinon 50 W	1.1 kg	10
		DZN 600 EW	0.915 L	10

PEA

Cultivars

The varieties listed in Table 5–37, *Pea Cultivars*, right, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. In some cases, other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under Ontario growing conditions. Varieties of crops change frequently; check with a range of seed company representatives for additional recommendations and variety descriptions.

Seeding

Date: As early as possible. Sowing of acreage for processing is now scheduled on the basis of accumulated heat units.

Rate: 250– 400 kg/ha depending on seed size and percentage of germination.

Depth: During April and early May, soil moisture is usually adequate, and seed can be sown 2.5–4 cm deep. For later seedings, a depth of 4–5 cm may be necessary.

Fertilizer

Nitrogen

Where phosphate and potash are required, 15 kg N/ha is recommended at seeding. If no phosphate and potash are required, the nitrogen may be omitted.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 3–5, Table 3–6 and Table 3–7 on page 24 and page 25.)

Application

Fertilizers should be broadcast and worked in before seeding. Do not drill fertilizer with the seed.

TABLE 5–37.
Pea Cultivars

Fresh Market		
Sugar Snap types	Little Marvel	
Progress types	Utrillo	Knight
Processing	As recommended by processors	

Disease Management

Root Rot, Wilt and Near-Wilt

Follow a 4-year rotation and other good management practices such as:

1. Select and plant only in well-drained fields.
2. Minimize soil compaction.
3. Work fields immediately after harvest.
4. Plant a green-manure crop such as sorghum, Sudan grass or fall rye.

Insect Management

Seed Maggots, Wireworms and Seed Decay

Treat seed with diazinon (organophosphate group), lindane (polychlorocycloalkane group) and a fungicide. See the section *Chemical Seed Treatment* on page 11.

Pea Aphid

This aphid is usually more abundant when peas are grown adjacent to clover or alfalfa. Various methods of sampling are carried out by fieldpersons to tell whether sprays are required. See Table 5–38, *Pea Aphid Control Recommendations*, below, for recommendations.

Pea Weevil

Infested seed should be fumigated. Use a commercial grain fumigant. For more details, consult the OMAFRA Factsheet, *Peas for Processing*, Order No. 81-054.

TABLE 5–38.
Pea Aphid Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
dimethoate	organophosphate	Cygon 480 E	275–425 mL	3	Do not feed or graze vines within 21 days of last application.
		Lagon 480 E	275–425 mL	3	
malathion	organophosphate	Malathion 25 W	4.25 kg	3	
		Malathion 500 E	2.25 L	3	
parathion	organophosphate	Parathion 960 EC	225–450 mL	14	Do not permit animals to feed or graze within 15 days of last application. Minimum period for re-entry is 7 days.
pirimicarb	carbamate	Pirimor 50 DF	150–275 g	6	
naled	organophosphate	Dibrom EC	1.1–2.2 L	4	Processing only.
methomyl	carbamate	Lannate SP	51 g	1	Minimum period for re-entry is 24 hours.
endosulfan	chlorinated cyclodiene	Thiodan 4EC	1.5–2.0 L	7	Processing only. Maximum 2 applications per season.
		Thiodan 400C	1.5–2.0 L	7	Processing only. Maximum 2 applications per season.

PEPPER

Cultivars

The cultivars listed in Table 5–39, *Pepper Cultivars and Descriptions*, on page 100, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. In some cases, other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under Ontario growing conditions. Varieties of crops change frequently; check with a range of seed company representatives for additional recommendations and variety descriptions.

Seed Treatment

Sow hot-water-treated seed. (See the section *Hot-Water Treatment* on page 11.) Before sowing, dust seed with thiram (dithiocarbamate group) seed protectant.

Seeding and Spacing

Two hundred grams of seed should produce enough transplants for a hectare.

Transplants

A standard planting arrangement for pepper crops is single rows with 1.0 m between rows and 45 cm between plants within the row (9,000 plants/ac). Some early, small plant type varieties may be planted at 1 m between rows and 30 cm between plants. Peppers may also be planted on twin rows at 1.5 m centres, with 45 cm between the twin rows, and 45 cm between plants within the row.

Pepper crops may be established from southern bare-root or greenhouse-grown transplants. Experience has shown that greenhouse-grown transplants are more reliable and have less potential for severe disease problems. Greenhouse-grown seedlings should be grown in plug-type containers to reduce the amount of root damage during transplanting. Larger cell sizes such as 72- or 98-cell trays promote higher early yields and are recommended for early fresh market crops. Otherwise, for main-season fresh market and processing crops, the 200-cell tray is recommended. Smaller cell sizes may be used but these require more management, such as watering. Consult the OMAFRA Factsheets *Growing Vegetable Transplants In Plug Trays*, Order No. 96-023, and *Pepper Production*, Order No. 91-047.

Plasticulture

Research has demonstrated that the use of plasticulture (plastic mulches, row covers and drip irrigation) can improve the production of peppers. Since these practices are relatively expensive, they are likely more suitable for fresh market pepper production. Black plastic mulch is recommended for peppers because it warms the soil, retains moisture and controls weed growth. Twin row culture is recommended on plastic mulch. See also the section *Plasticulture* on page 42.

Earlier production of peppers may be achieved by planting 10–14 days earlier than normal and covering the crop with a white plastic row cover. This cover should be opened for ventilation when the temperature inside reaches 35°C or higher. The cover should be removed in early June or whenever conditions are favourable for good growth.

Fertilizer

Nitrogen

Apply up to 70 kg N/ha. If manure is applied or legume sod is plowed down, reduce the nitrogen application. (See Table 3–10 and Table 3–11 on page 28 and page 29.)

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 3–5, Table 3–6 and Table 3–7 on page 24 and page 25.)

Application

Broadcast 35 kg N/ha and all of the phosphate and potash required before planting and work in. The remainder of the nitrogen should be side-dressed after first fruit set, if required.

Starter Solution

At transplanting, apply a starter solution high in phosphorus such as 1 L of 10-34-0 per 100 L of water or 1 L of 6-24-6 per 75 L of water. Under high temperature conditions or in dry sandy soils, reduce the amount of fertilizer by half but continue to use the same volume of water. This will reduce the risk of crop injury under these growing conditions.

Disease Management

Damping-Off

See the sections *Seed Treatment* and *Hot-Water Treatment* on page 11 and *Damping-Off of Seedlings* on page 12. Because unsterilized soil and mixes containing peat moss, pit sand and soil often give rise to damping-off, sow and

TABLE 5–39.
Pepper Cultivars and Descriptions

Cultivar	Description
SWEET PEPPERS	
Bells for Harvest at Mature Green Stage	
Aladdin X3R	Main season, medium-to-large, blocky fruit, 3-way resistance to bacterial leaf spot.
Bell King	Consistent good yield, blocky, half-long fruit, excellent canopy gives good fruit protection.
Boynton Bell	Mid-season, continuous set, medium-large fruit, smooth, excellent quality, 3-race resistance to bacterial spot.
Emerald Isle	Similar shape to Boynton Bell, elongated block, slightly earlier than Enterprise.
Enterprise	Early mid-season maturity, blocky, large fruit, concentrated maturity, 3-race resistance to bacterial spot.
Ironside X3R	Cultivar description not available here, consult seed catalogues.
Karma (trial)	Slow to turn red, early-to-mid-season, good plant cover, elongated block.
King Arthur	Early mid-season maturity; very large, blocky, 4-lobed fruit, uniform red at maturity; resistant to race 1 of bacterial leaf spot.
Merlin	Mid-season, good fruit size and yield potential, blocky fruit, ripens to a uniform red colour.
Red Knight X3R	Cultivar description not available here, consult seed catalogues.
Wizard X3R	Cultivar description not available here, consult seed catalogues.
Bells for Harvest at Ripe Fruit Stage	
Red	
Century X3R	Square, blocky, mid-season, attractive, red.
Ironside X3R	Cultivar description not available here, consult seed catalogues.
Merlin	See above.
Red Knight X3R	Cultivar description not available here, consult seed catalogues.
Redstart	Very early maturity; medium-sized, tapered, bell-shaped fruit; uniform colour when ripe; recommended for early red pepper fresh market or processing.
Wizard X3R	Cultivar description not available here, consult seed catalogues.
Yellow	
Aladdin X3R	See above.
Flamingo	Hungarian, sweet-type pepper; fruit is medium sized, taper bell, with thick walls and very sweet flavour; yellow at maturity, turns orange to red when ripe.
Klondike Bell	Early mid-season; large, blocky fruit, ripens from green to yellow-orange.
Supersweet 860	Mid-season; large, blocky bell; ripens green to yellow; very smooth fruit; high yield potential when harvested either green or yellow.
SWEET BANANA	
Banana Supreme	Early, concentrated fruit set, yellow to orange to red, good wall thickness.
Golden Arrow	Early, large concentrated fruit set, matures yellow, orange to dark red.
Sugar Banana	Large, very thick wall, good yielder, Super Shepherd type.
SWEET RAMSHORN	
Laparie	Elongated, pointed fruit, Italian type pepper, fruit approximately 20 cm long, high yielder.
Super Shepherd	Early, productive, with 15–18 cm pointed pendant fruit with thick walls.
HOT PEPPERS	
Copacabana	Smooth, tapered fruit, 15–20 cm long, ripens waxy yellow to orange to red, heavy fruit set with good foliage cover.
Crimson Hot	Hot pickling/fresh chili type; 14 cm long and 3.5–4.0 cm at the shoulder, fruit turns dark red, sits high on a fairly large plant.
Diablo Grande	Large, tapered fruit, light green, ripens to red, larger than most other hot peppers.
Hot Spot	Cultivar description not available here, consult seed catalogues.
Hungarian Medium Hot	Cultivar description not available here, consult seed catalogues.
Inferno	Hybrid hot banana type; very uniform, long, straight fruit, ripens from yellow to red.
Super Hungarian Hot	Cultivar description not available here, consult seed catalogues.
Surefire	Very pungent, long, tapered/pointed fruit, good foliage cover.
Volcano	Hot Hungarian wax type, good foliage protection for fruits, which are yellow when young and bright red when mature; consistently a good yielder.
MINI (NOVELTY)	
Jingle Bells	Yields a profusion of small (4 cm x 4 cm), blocky fruit. When harvested either green or red, these fruit are well-suited for the restaurant trade (garnish or salad bar) or as a stir-fry item.
PIMENTO	
Creamy Cheese	Small- to medium-sized fruit ripens yellow to orange to red. Small-to-medium plant with very heavy fruit set.
Super Red Pimento	Very large, flat-shaped fruit, dark green to red. Plants are medium to large with good foliage canopy.
Yellow Cheese Pimento	Large, squash-shaped fruit, ripens green to yellow to orange. Large plant with good fruit set.

TABLE 5–40.
Pepper Disease and Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Bacterial Leaf Spot					
copper hydroxide	inorganic	Champion 50 WP	2.25–3.25 kg	1	
		Kocide 101 WP	2.25–3.25 kg	1	
		Kocide DF	2.25–3.25 kg	1	
Aphids					
pirimicarb	carbamate	Pirimor 50 DF	275–550 g	3	
dimethoate	organophosphate	Cygon 480 E	0.7–1.0 L	3	
		Lagon 480 E	0.7–1.0 L	3	
diazinon	organophosphate	Diazinon 50 WP	1 kg	5	Note: control of aphids with diazinon has been inconsistent in many areas.
		DZN 600 EW	0.46–0.915 L	5	
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.0–2.25 kg	2	
		Thiodan 4 EC	1.5–2.5 L	2	
		Thionex 400 EC	1.5–2.5 L	2	
acephate	organophosphate	Orthene SP	0.75 kg	7	Green peach aphid only.
European Corn Borer					
deltamethrin	pyrethroid	Decis 5.0 EC	250–300 mL	3	
permethrin	pyrethroid	Pounce 384 EC	180 mL	1	
carbofuran	carbamate	Furadan 480 F	1.1 L	3	Minimum period for re-entry is 48 hours. Do not use more than 3 applications/season.
carbaryl	carbamate	Sevin XLR Li	2.5–5.25 L	2	In areas where corn borer has been a problem, spray every four days.
acephate	organophosphate	Orthene SP	1.1 kg	7	Do not use more than 4 applications/season.
Pepper Maggot					
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.1 kg	2	
		Thiodan 4 EC	1.5 L	2	
		Thionex 400 EC	1.5–2.5 L	2	
malathion	organophosphate	Malathion 500 E	1.25–2.75 L	3	
dimethoate	organophosphate	Cygon 480 E	0.7–1.0 L	3	
		Lagon 480 E	0.7–1.0 L	3	
acephate	organophosphate	Orthene SP	0.75 kg	7	Do not use more than 4 applications/season.

transplant only in a sterilized medium. Drench flats at time of first watering with captan (phthalimide group) 50 WP or 80 WP (see label). Spray when first true leaves develop, with Captan 50 WP 2.25 kg and repeat every 7–10 days. Apply sufficient spray to wet plants and run down stems.

Bacterial Leaf Spot

It is not possible to completely control this disease with chemical sprays. A reduction in the number of lesions may be acheived through the application of copper bactericides. In periods of extended wet weather and extensive disease pressures, control using copper materials may not be satisfactory. Use one of the fungicides recommended in Table 5–40, *Pepper Disease and Insect Control Recommendations*, above.

Some varieties have tolerance to bacterial spot races 1, 2 and 3 listed as X3R.

Virus Diseases (CuMV, TSWV)

Aphids may vector virus diseases such as cucumber mosaic virus (CuMV) to peppers. Monitor and control aphids regularly (see the section *Aphid* on page 102).

The Western flower thrips (WFT) may occasionally vector the tomato spotted wilt virus (TSWV) to field peppers. The WFT is a small (1–2 mm) insect that can easily be confused with onion thrips. Regular and consistent monitoring for both thrips and potential virus symptoms in transplant houses and the field is necessary. No insecticides are labeled currently for thrips on field peppers.

Other viruses may affect peppers but are not common in Ontario. These include alfalfa mosaic, potato virus Y and tobacco etch. Consult the OMAFRA Factsheet *Pest Management of Thrips on Greenhouse Vegetables,* Order No. 94-023.

Verticillium Wilt

Grow seedlings in sterilized soil. Fumigation may be necessary if field soil populations are high. Crop rotation with non-host crops is recommended. The incidence of wilt may be higher following peppers, tomatoes, eggplant, potatoes, strawberries and raspberries. See the section *Crop Rotation for Control of Diseases* on page 13.

Insect Management

Aphid

Examine the undersides of leaves on 50–100 plants. If monitoring indicates a need, spray with one of the pesticides recommended in Table 5–40, *Pepper Disease and Insect Control Recommendations,* on page 101. Natural enemies will provide significant control of aphids.

Tarnished Plant Bug

If monitoring indicates a need, dimethoate (organophosphate group), as recommended for aphids (see Table 5–40 on page 101), will give some control of tarnished plant bugs.

For more information, consult the OMAFRA Factsheet *Tarnished Plant Bug Damage on Vegetable Crops in Ontario,* Order No. 98-025.

Corn Borer

Peppers are susceptible to corn borer attack when the fruit are the size of walnuts and must be protected from then until harvest if corn borers are present. Monitoring populations of European corn borer provides information on adult flight patterns. For chemical control, thorough distribution of spray material is required. If a hydraulic boom sprayer is used, solid- or hollow-cone nozzles on drop pipes provide improved coverage.

Use one of the pesticides recommended in Table 5–40 on page 101.

For more information consult the OMAFRA Factsheet *European Corn Borer in Sweet Corn and Other Horticultural Crops,* Order No. 97-019.

Pepper Maggot

In areas where this is a problem and monitoring indicates a need, apply 4 sprays at 7-day intervals starting the last week of June or first week of July using one of the pesticides recommended in Table 5–40 on page 101.

Potato Leafhopper

Potato leafhopper is an unusual and sporadic pest of peppers. Damage to leaf margins appearing as leaf scorch may be observed. If monitoring indicates a need, endosulfan (chlorinated cyclodiene group), malathion (organophosphate group) and carbaryl (carbamate group) (at 1.25 L/ha) as listed in Table 5–40 on page 101 for pepper maggot and corn borer, may provide some control.

Thrips

See the section *Virus Diseases (CuMV, TSWV)* on page 101.

Nematode Control

See the section *Nematodes* on page 17.

Visit the vegetable page on the OMAFRA Web site at http://www.gov.on.ca/OMAFRA/english/crops/hort/vegetable.html

POTATOES

Cultivar Descriptions

Listed in order of maturity.

TABLE 5–41.
Potato Cultivars Grown in Ontario and Their Main Uses

Table Stock	Processing	Low Acreage or Specialty
Superior (main early)	Andover (field chipper)	Jemseg (very early)
Shepody (main storage)	Atlantic (main field chipper)	Conestoga (early, table)
Kennebec (storage)	Monona (long storage chipper)	Red Gold (red skin, yellow flesh)
Chieftain (main red)	Superior (pre-peel)	Temagami (red skin)
Norland (early red)	Shepody (pre-peel)	Keswick (table storage in North)
Novachip (table)	Kennebec (pre-peel)	Ruby Gold (rose skin, yellow flesh)
Yukon Gold (main yellow flesh)	Snowden (storage chipper)	Royal Gold (royal purple skin, yellow flesh)
Cherokee (fancy bulk)	Novachip (storage chipper)	
Eramosa (very early)	Niska (storage chipper)	
Niska (table)		
Onaway (midseason)		

Early Maturity

Jemseg – Very early maturity but better planted once the soil reaches 10°C; smooth, blocky tubers; good yield; early-season boiler; tubers oversize very quickly; tubers allowed to oversize usually develop hollow heart; not a storage potato; immune to virus X; resistant to viruses Y and S; moderately resistant to common scab; susceptible to leafroll, *Verticillium* wilt and *Fusarium* storage rot; cut seed should be held and suberized before planting. Due to poor eye distribution, large seed tubers (over 250 g) are best cut by hand to avoid poor stands from blind seed pieces.

Eramosa – Very early maturity but better planted after the soil reaches 10°C as it emerges slowly; smooth, round, flattish tubers with good flavour and quality; sets and sizes evenly; vines are very determinate, sets very few flowers; tuber skin is attractive; moderately susceptible to scab and virus Y; not prone to oversizing and has some field tolerance to leaf roll; seed should be well-warmed or chitted prior to planting. Cut seed should be held to suberize (form a callus) at least one week before planting.

Superior – Ontario's most widely planted potato. Early; fairly smooth; high yield; good for tablestock; as a mid-summer chipper, it is sometimes variable in quality; stress (drought or disease) reduces yields substantially; resistant to scab but very susceptible to *Verticillium* wilt, root lesion nematode and early dying.

Conestoga – Early; blocky, medium smooth; very vigorous early growth; yield comparable to Superior; good boiler; moderately resistant to leaf roll, early blight and common scab; moderately susceptible to mild and rugose mosaic. A slight bitterness in the tuber flesh may be observed if this variety is harvested either very immature or when grown under very stressful conditions.

Norland – Early Red. Very susceptible to air pollution and moisture stress. Tolerant to common scab. Avoid the herbicide metribuzin post-emergence. Tubers are smooth, oblong, slightly flattened and shallow eyes. Red skin colour decreases after tubers mature. Tubers are very susceptible to growth cracks when crop is under heat and moisture stress. Dry matter is low. Good storability. Some clones with a darker red colour are now available.

Mid-Season

Redgold – Medium early; round, rose-skinned tubers with deep yellow flesh; sets heavily, may fail to size well and has only average dry matter but good flavour. Will sprout readily after harvest where most cultivars require several weeks to break dormancy. Susceptible to ozone injury. A specialty potato for the "technicolour trade."

Yukon Gold – This variety has a very good reputation in Ontario. Medium-early; tubers round, smooth; yellow-fleshed with pink eyes; good flavour; medium-high yield; good boiling, baking and French-fry quality; tall, upright plants; moderately susceptible to common and pitted scab, virus Y, ozone and silver scurf; resistant to mild mosaic and leaf roll; resists after-cooking discoloration; excellent keeping potato; cut seed is best held to suberize (form a callus) before planting to avoid poor stands; plant close (20–25 cm) in row to avoid oversizing and possible hollow heart.

Cherokee – This variety is a favourite in the Ontario fresh market when washed and offered in bulk. Medium early, medium yield potential and good keeper in storage. Tubers have one of the whitest skins of any variety; medium-deep eyes and good flavour. Misshapen tubers may be a problem under adverse weather conditions;

resistant to common scab and some races of late blight; susceptible to *Verticillium* wilt and leaf roll.

Andover – Field chipper. Not a strong crop but the chip colour is always good with low defects. The vines decline rapidly under heat and drought stress. The margins of the leaflets become brown, roll up; this symptom can be confused with leafhopper damage.

This variety is very susceptible to early dying. The seed has a slightly longer dormancy than Superior and should be warmed before cutting, treating and planting.

Seed spacing should be 20–22 cm (8–9 in.) apart. About 68 kg (150 lb) of actual nitrogen should be adequate. It is preferable to split the application, e.g., 36–46 kg (80–100 lb) at planting and the balance at hilling or some proportion that makes sense for your operation. Soil with only 2–2.25% OM and a Cation Exchange capacity of 7 or 8 may not be able to hold more than 32 kg (70 lbs) of nitrogen in the event of a heavy rain after planting.

Atlantic – Regarded as a major variety for field chipping. Mid season maturity; round, smooth; medium-netted tubers; high yield and dry matter, vigorous plant; chips excellent out of the field; seldom used as a storage chipper in Ontario; tolerant to *Verticillium* wilt; resistant to virus X, pink eye, but susceptible to internal heat necrosis in hot soils, *Fusarium* dry rot in storage and hollow heart, and post-emergent applications of metribuzin. Moderately susceptible to metribuzin applied pre-emergent on low organic-matter soils; susceptible to harvest bruising and pressure bruising in storage.

Onaway – Adapted to sandy soils well supplied with organic matter. Requires close spacing to prevent the production of large, rough tubers. Tubers have medium deep eyes, white skin slightly flaked at maturity, white flesh and high dry matter. Fair for boiling and baking, unsuitable for processing. Does not store well. Because of the pectin content of the tubers, a few more minutes are required for cooking. This variety is tolerant to common scab but susceptible to blackleg, *Verticillium*, leaf roll and *Fusarium* dry rot.

Keswick – Not recommended in areas south of North Bay. Main crop season; light green foliage; fairly smooth under close spacing; good cooking quality; makes good mid-season French fries; tolerance to scab, late blight and hollow heart; susceptible to virus Y, *Fusarium* dry rot and mosaic.

Main Crop

Monona – Roundish, white-skinned, medium-eyed tubers, medium to good yield; low in dry matter; chiefly used as a long-term 10°C storage chipper; not recommended for table stock; resistant to virus Y and A, and tolerant to *Verticillium* wilt; moderately susceptible to hollow heart and blackleg; requires good storage ventilation.

Chieftain – Most widely grown red-skinned variety in Ontario; fairly smooth, round; red skin, very white-fleshed tubers, sets heavily; high yield; low dry matter; good boiler but doesn't process; susceptible to internal heat necrosis, *Verticillium* wilt, blackleg, virus X and Y; moderately resistant to common scab, *Rhizoctonia* and stem end browning; skin must be mature to avoid feathering at harvest; susceptible to shattering under wet soil conditions coupled with wide differences in air and ground temperature; susceptible to heat necrosis.

Kennebec – Heavy vigorous plant; tubers thin-skinned, sets light and may oversize; plant under close spacing 20–25 cm; very high yield and medium dry matter and good flavour; do not use more than 130 kg of nitrogen; chips but does not store reliably in 10°C storage; fair French-fry quality; tubers green rapidly under light; resistant to virus A and Y, visual field mosaic, and drought; very susceptible to *Verticillium* wilt and pink eye; moderately susceptible to common scab, late blight tuber-rot and leafroll.

Shepody – Medium-late main crop. Most important variety bred in Canada and the leading storage table stock potato in Ontario; large, oblong, smooth-eyed and smooth-skinned tubers; a late sizer; good-to-medium high yields, although lower performance in very hot growing seasons; excellent baker, boiler and French-frier; good pre-peeler; does not chip out of storage; medium dry matter; moderate resistance to early blight, *Fusarium* dry rot and *Rhizoctonia*; susceptible to common scab, *Verticillium* wilt, late blight and virus Y and S; very susceptible to mild mosaic and post-emergent applications of the herbicide metribuzin. Pre-emergent applications of metribuzin on low organic-matter soils may also cause damage; good resistance to tuber shattering. Maintain aphid control, as Shepody is not totally immune to net necrosis. Does not perform well in very hot climates. Sealing soil cracks prior to vine killing reduces tuber greening.

Novachip – Late main crop, persistent upright vine with stalk rot resistance; elongated thick and wide white-skinned tubers, very smooth, shallow-eyed; medium-to-

low setter; good tolerance to hollow heart and off-type tubers; a good sizer; only fair tolerance to scab, *Verticillium* wilt and pink eye. A storage chipper (maybe long-term) but not as white a chip nor the in-plant yield of Snowden. Novachip, however, has a dual use as a decent table stock product.

Niska – Late main crop vigorous foliage; white-skinned elongated tubers with medium deep eyes; good sizer medium dry matter; skin sets well after top killing; only fair tolerance to scab and *Verticillium* wilt and somewhat prone to tuber late blight; clean-fleshed and good hollow heart resistance; not as good in-plant yield and percentage defect-free chip record as Snowden; a storage chipper with good table stock quality.

Snowden – Late main crop. Storage chipper and standard for in-plant yield and defect-free chip production; responds to good management (unforgiving if neglected); late-to-very late; medium netted round tubers; good-to-high dry matter; deep rooted. It sets tubers deeper and to the edge of hills. It can be a poor sizer, responds to additional nitrogen and should be planted at 30–35 cm within the row. Moderately susceptible to scab (surface and pitted), *Verticillium* wilt and blight. Care is required at harvest to prevent bruising and black spot. Frying-wise, Snowden recovers from shock better than most chippers.

Temagami – Medium-late maturity, good vine vigour and yield potential; red-skinned, white-fleshed, better flavour than Chieftain but lower tuber set; moderately susceptible to scab.

Royal Gold – Novelty variety with a high "bloom," royal purple skin and yellow flesh; excellent for exhibiting. This variety has a good-looking vine but is prone to air pollution, and is often a poor sizer resulting in lower yield potential.

Ruby Gold – Late, main crop specialty variety with rose skin and a pleasing yellow flesh. Vine has good staying power and bulks well at season's end with good yield potential; tubers have definite eyebrows and are thick and elongated; tuber set is medium, a good sizer with hollow heart tolerance; moderately prone to scab.

Transgenic or Genetically Modified (GM) Varieties

GM varieties have had the Bt gene inserted, which provides built-in protection against Colorado potato beetle and provides season-long control of this pest. The Bt gene induces the plants to produce a protein that kills Colorado potato beetles when they feed on the foliage, although they do not appear to die when they feed on tubers of GM varieties.

The GM Shepody variety also has built-in resistance to potato virus Y.

Note: GM varieties are attacked by other insects such as leafhoppers and aphids, which can cause serious damage if left uncontrolled.

Cultivar Descriptions of GM Varieties

Superior: NL10-SUP – The New Leaf Superior is very different from the standard Superior. It produces vigorous, upright plants that tend to stay green longer. The extensive root system allows the crop to be grown with less nitrogen fertilizer than the regular Superior. Optimum nitrogen fertilizer rates for New Leaf Superior appear to be 20–25% less than for standard Superior.

Too much nitrogen promotes excessive vine growth and delays tuber set together with vine and tuber maturity. Marketable yields seem to be higher at 20–25-cm (8–10-in.) spacing. Wider spacings may result in too many over-sized tubers with less attractive type.

In Ontario trials, this variety has shown high susceptibility to pink eye and matures later than the standard Superior.

Atlantic: NL10-ATL – There are 3 New Leaf Atlantic lines — New Leaf 6 Atlantic, New Leaf 31 Atlantic and New Leaf 36 Atlantic. The seed of these 3 lines shows longer dormancy than the standard Atlantic cultivar. Avoid planting at depths greater than 10–12 cm (4–5 in.) or in cold soils. The fertility requirements are the same as the standard Atlantic. If split applications of nitrogen are used, apply the last application before extensive tuber bulking. Late season nitrogen application can intensify internal tuber defects.

The New Leaf 31 Atlantic line shows a tendency for earlier bulking and maturity and should be harvested at or before 100 days after planting. Late or delayed harvest can result in very high tuber necrosis defects.

Shepody: NL20-SHE – This line provides season-long control of Colorado potato beetle and potato virus Y (mosaic). Seed is more dormant than that of the standard Shepody variety and requires additional warming to encourage rapid emergence. There are 2 lines of New Leaf Shepody — New Leaf Y 2 Shepody and New Leaf Y 15 Shepody. Both lines show a trend for higher yields at

9–18 kg/ha (8–14 lb/acre) more nitrogen than what is optimum for Shepody.

Seeding Rate, Spacing and Depth

The amount of seed needed for planting depends mainly on the spacing within the rows and on the characteristics of the variety.

A healthy 1.5–2-oz seed piece is considered best to establish a vigorous plant. Plants from seed pieces smaller than 1.5 oz are generally slower to emerge and have less vigour. Small seed pieces are also more likely to decay before the plant becomes established. Seed pieces cut larger than 2 oz result in higher seed costs with little potential benefit.

The distance between rows is usually 90 cm (36 inches).

Seed spacing is based on variety characteristics such as tuber set, resistance to hollow heart and resistance to the development of off-shaped tubers.

Wider spacing (30–32 cm or 12–13 in.) is recommended for varieties with heavy tuber set, smooth tubers and resistance to hollow heart and off-shape tubers. Closer spacing (20–25 cm or 8–10 in.) is recommended for varieties with lower tuber set to reduce the number of oversized tubers.

Seed potatoes are planted near ground level and covered with 5–8 cm (2–3 inches) of soil by the planter.

Sanitation

The storage area and all potato equipment, including cutting knives and containers, should be completely cleaned before using. Clean out and thoroughly scrub with detergent all machinery, equipment, walls, floors, etc., then use a quaternary ammonium compound labelled for bacterial ring rot control.

Disinfectants are inactivated by organic matter, so are only effective on clean surfaces. The surface should remain wet 20 min after the disinfectant is applied. Cull piles may be buried deeply in marginal land or taken to a sanitary dump site. Exposed cull piles are not desirable, as they are food sources for Colorado potato beetles, maggot flies and innoculum sources of late blight spores. Control vine growth on cull piles with a suitable vine killer.

Seed Potatoes

Seed potatoes fall into seed classes, as shown in Table 5–42, *Canadian Seed Classes*, above.

TABLE 5–42.
Canadian Seed Classes

Class	Field Generation[1]
Nuclear	Greenhouse Laboratory
Pre Elite	1
Elite I	2
Elite II	3
Elite III	4
Elite IV	5
Foundation	6
Certified	7

[1] Seed drops a class each year in the field if it passes inspection.

Seed Sources

The availability of seed of new or specialty cultivars can often be limited. To ensure a supply of seed, contract with your seed growers. For information on contracting and seed availability lists, contact the Ontario Seed Potato Growers Association at 109 Hutchinson St., Alliston, Ontario, L0M 1A0 Fax: (705) 435-5661.

Seed Handling and Management

Plant Elite or Foundation Class seed to reduce leaf roll, mosaic and bacterial diseases. Inspect seed on arrival for heating, freezing, grade and visual tuber disease. Seed lots can be regraded by your local Agriculture Canada seed potato inspector in some cases. Request for reinspection must be made within two working days of receipt of the seed potatoes.

Request at least two certification tags with each bulk load — one for your bin and one for your files. The tag number gives you direct access to the seed grower. Handle, store and plant the seed carefully. Poor stands and field performance are not always the seed grower's fault. During cutting, discard tubers and seed pieces showing rot.

Pad all seed-handling equipment as you would harvest equipment and reduce drops to less than 15 cm to reduce bruising. Ensure that cutter knives are sharp. As cold storage temperatures make seed tubers more sensitive to bruising, warm seed to at least 5°C prior to handling. Ideally, seed should be around 10°C for cutting. Bruising acts as an entry site for pathogens leading to seed piece decay. Mishandling seed may physiologically age seed, leading to more stems per plant, smaller tubers and more stress susceptibility.

Several physiological factors influence stand, for example, physiological age of seed, apical dominance, eye distribution and variety. "Middle-aged" seed emerges

faster than young or excessively old seed. Varieties with strong apical dominance, such as Jemseg and Yukon Gold, will produce uneven stands when using cut seed because of the delay in emergence from non-apical buds.

Varieties with weak apical dominance, such as Superior, produce more uniform stands from cut seed. Eye distribution on seed tubers is important, as some varieties have even eye distribution (Superior) while others have eyes concentrated at the apical end. When cut by machine, the latter varieties produce a large proportion of blind seed pieces. Large tubers accentuate the problem and should be graded out and cut by hand. Check seed coming off the cutter frequently for size, blind pieces and slivers, and adjust if necessary.

The physiological age of seed affects the performance of the crop. The rate of aging depends on cultivar and temperature. Varieties can have short (Redgold), intermediate (Superior) or long dormancies (Yukon Gold, Jemseg, Eramosa). Long-dormancy types will require more aging than short-dormancy types. The rate of aging also increases with temperature. Old seed is desirable for earlies as it emerges faster and more uniformly, sets and bulks tubers earlier and matures faster than plants from young seed. Old seed is desirable for earlies, seed production and production in short-season areas.

In long-season areas, young seed is desirable for main crops to use the long bulking period. Old seed may result in lower yields of main crops as plants may be more stress prone. If seed is sprouted upon receipt, additional aging may result in excessively aged seed for main crops in long-season areas. Long periods of warming or curing at warm temperatures of such seed may result in excessive aging.

Cut seed not being planted immediately should be given special attention to ensure healing and suberization by:

- forced-air circulation through the shallow pile
- temperatures of 10°C–15°C
- high relative humidity in the air of 90–95% (prevent free water from forming on tuber surfaces)
- maintenance of these conditions for 3–4 days
- after this, temperature may be lowered but humidity must be maintained and fans run intermittently

Cut seed stored in boxes or bags should get the same conditions and be piled to allow good air movement around each container.

Never allow cut seed to stand in the hot sun or in drying wind. This causes minute cracks in the skin that allow bacteria and fungi to get established.

Do not plant seed tubers that have been washed.

Do not plant in hot, dry soil or cold, wet soil.

Do not plant potatoes immediately after plowing down a heavy green stand of rye or clover.

Seed Piece Treatment

This is an insurance application. Some years, there is no apparent advantage, but in other years there is an advantage. Gypsum-based coatings act as a drying agent but have no insecticidal or fungicidal activity. However, chemical seed piece treatments may contain one or both. Apply a dust at time of cutting with an application on the end of the seed cutter. See Table 5–43, *Potato Seed Piece Treatment Recommendations*, below.

TABLE 5–43.
Potato Seed Piece Treatment Recommendations

Common Name	Group	Trade Name	Rate per 50 kg seed
thiophanate-methyl	benzimadazole	Senator PSPT	250g
metiram	dithiocarbamate	Polyram 16 Dust	225–325 g
mancozeb	dithiocarbamate	Tuberseal	250 g
		Potato ST 16	250 g

Seed treatments that contain 16% mancozeb reduce the spread of late blight during cutting operations.

Seed cutting favours the spread of late blight, because the fungus produces spores readily on cut surfaces of infected tubers. After seed cutting, it can take only one day for the fungus to produce spores that will infect healthy seed pieces. A seed treatment with mancozeb should protect healthy cut seed from late blight infection.

The risk of disease spread increases with the length of time cut seed lots are held before planting, so the longer you store cut seed, the greater the risk of late blight.

Do not plant seed lots that are known to be infected with late blight.

Chitting or Green Sprouting

This process may be used for limited plantings, where early emergence and yield are important, or in short-season areas. Chitting is the process of aging seed in the

light to control sprout growth resulting in earlier emergence and sizing. Chitting will take several weeks, so plan well ahead of the expected planting date.

Small, whole seed is placed in shallow containers 2–3 tubers deep that allow for air movement and light penetration. Seed can be chitted in a building with fluorescent lights or natural light in a greenhouse. Short, stubby, dark-green spouts are desirable to minimize sprout damage at planting.

Chitting seed in cool temperatures (such as 8°C) under fluorescent light results in shorter sprouts than using warmer temperatures. Seed taken from winter storage of 3°C–4°C will require about 250 degree-days using a 4°C base. For each day, calculate as follows:

$$\text{Degree Day (DD)} = \frac{(\text{Max. Temp.} + \text{Min. Temp.})}{2} - \text{Base Temp}$$

For example, if the maximum temperature is 15°C, the minimum temperature is 5°C, and the base temperature is 4°C:

$$\text{Degree Day (DD)} = \frac{(15 + 5)}{2} - 4 = 6$$

At this rate, it would take approximately 41 days (250 DD ÷ 6) to green sprout the tubers. Green-sprouted tubers should be planted with cup or bell planters to reduce the chances of green-sprout injury. Avoid pick planters. Sized seed will improve the uniformity of emergence.

If a greenhouse is unavailable, seed can be chitted at 20°C in natural shaded light for about 2 weeks with similar results. The same can be accomplished inside a heated building. Higher levels of fluorescent light are required than at cool temperatures. In all cases, provide sufficient humidity to prevent dessication but not enough to stimulate rooting.

Soil

A soil pH of 6 to 7 is desirable for optimum growth of potatoes. However, lower pH values down to 5.0 may provide better control of scab. Apply limestone to rotation crops where possible, and in the fall if potatoes follow potatoes.

Soil organic matter can be maintained by use of well-decomposed barnyard manure, grass or legume sod crops, or cover crops. A thick cover crop seeded after early potatoes will reduce soil blowing and fertilizer leaching. Manure should be applied in the fall and incorporated.

Fertilizer

Nitrogen

Consult Table 5–44, *Nitrogen Recommendations for Potatoes*, below, for nitrogen requirements. If manure is applied or legume sod is plowed down, reduce the nitrogen application. (See Table 3–10 and Table 3–11 on page 28 and page 29.)

TABLE 5–44.
Nitrogen Recommendations for Potatoes

Soil Type	Recommended Rate (kg N/ha)	Expected Marketable Yield (t/ha)
Mineral –Main Crop	50	15
	75	20
	130	25
	200	30+
Mineral – Early Crop	70	
Muck – Early and main crop	up to 60	

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 3–5, Table 3–6 and Table 3–7 on page 24 and page 25.)

Application

On mineral soils testing medium or low for phosphate, some or all of the phosphate fertilizer should be placed in bands 2.5 cm below and 6 cm to each side of the seed piece at planting time. On muck soils or on mineral soils testing high for phosphate, placement is less critical and fertilizer may be broadcast.

If the total nitrogen plus potash applied is over 360 kg/ha, at least a portion should be broadcast before planting to avoid concentrating the fertilizer band near the seed piece and potato roots. Broadcasting or side-dressing nitrogen after potatoes are 20 cm high is not generally recommended because it may delay maturity.

Plant Analysis

Samples for plant analysis should be taken from at least 50 plants distributed throughout the area chosen for sampling. Problem areas should be sampled separately.

For potatoes, the fourth leaf, including stem, from the growing tip at early bloom is recommended. However, plants suspected of nutrient deficiency should be sampled as soon as the problem appears. Expert help will be required to interpret plant-analysis results when the samples are not taken at early bloom. A soil sample

TABLE 5–45.
Interpretation of Plant Analysis for Potatoes
Values apply to the fourth leaf, including stem, from the growing tip at early bloom.

Nutrient	Units	Critical Concentration[1]	Maximum Normal Concentration[2]
Nitrogen	%	2.50	3.50
Phosphorus	%	0.15	0.50
Potassium	%	1.20	2.50
Calcium	%	1.50	
Magnesium	%	0.10	0.60
Sulphur	%	0.14	
Boron	ppm (ug/g)	2	25
Copper	ppm	2	25
Manganese	ppm	15	150
Zinc	ppm	14	70

[1] Yield loss due to nutrient deficiency is expected with nutrient concentrations at or below the "critical" concentration.
[2] Maximum normal concentrations are more than adequate but do not necessarily cause toxicities.

should be taken from the same area and at the same time as a plant sample. For more information on plant analysis see the section *Plant Analysis* on page 20.

Disease Management

Practice a suitable crop rotation to prevent build-up in the soil of organisms causing *Verticillium* wilt, *Rhizoctonia*, common scab and early blight.

Seed-Piece Decay

See the section *Seed Handling and Management* on page 106.

Note: Seed piece treatments will not control bacteria.

The leading cause of potato seed piece breakdown after planting is *Fusarium* dry rot. Modern potato handling equipment, such as harvesters, bulk unloaders and bin pilers ensure the *Fusarium* fungus in the soil is mixed thoroughly over the seed tubers at harvest. Initially there may be no visual evidence *Fusarium* is there. A "bag test" is recommended one or two months after storage to assess the *Fusarium* concentration. Select 20 tubers from the face of the pile, cut them in quarters if small or in eighths if larger and drop them in a new 10-lb potato bag. Shake the bag vigorously for a minute to inoculate the freshly cut seed. Fold the paper bag over loosely, place it inside a plastic garbage bag that is also folded over loosely and place it in your basement where the temperature will be 16°C–18°C (60°F–65°F). Let the bag sit for 3– 4 weeks. If more than 30% of the seed pieces show visual *Fusarium* infection, there is a potential high incidence of seed piece decay.

Rhizoctonia

Rhizoctonia can cause severe losses when soil conditions are cold and wet and/or potatoes are grown in short rotations. Symptoms include poor emergence, stem and stolon cankers, aerial tubers, leafrolling, premature death of plants and tuber malformations.

Usually, on infected plants, a grayish white mycelium develops on the stems just above the soil line. The black sclerotia or black scurf that develops on tuber surfaces cause serious losses for tablestock growers.

Rhizoctonia populations increase in soil where little or no rotation is practised. Planting seed tubers that are heavily infested with sclerotia also favours inoculum build-up in soil.

To reduce the incidence of *Rhizoctonia*, avoid land known to be heavily infested. Rotate the crop with, for example, spring barley on mineral soil or onions on muck soils. See the section *Seed Handling and Management* on page 106.

Verticillium Wilt

This fungal disease has a very wide host range and is very persistent in the soil. In combination with nematodes, *Verticillium* wilt causes premature die-back syndrome. Test soils for *Verticillium* levels (see the section *Nematodes* on page 17). If *Verticillium* and/or nematode levels are high, row or broadcast fumigation gives a quick fix. Otherwise, incorporate long-term rotations with non-host crops, or plant cereal cover crops after early potato harvests to control weed hosts. Increasing soil tilth promotes stronger, healthier potato roots.

Early Blight

Early blight is a very common fungal disease of potatoes that is more severe when the crop is under stress. The typical symptoms of this disease are dark-brown to black spots with concentric rings. The spots are often irregular in shape. Symptoms develop first on the older leaves of mature plants spreading to the younger leaves under favourable weather conditions. Begin the fungicide spray program early so that lower plant foliage is well covered. Conditions favourable for disease development are combinations of temperatures between 17°C–24°C and 12 hours of leaf wetness throughout the plant canopy. In addition, stress conditions such as drought, insect damage, air pollution and rapid growth at tuber sizing increase the

foliar susceptibility to early blight. Under these conditions, spray intervals should be shortened to 7 days.

Late Blight

The late blight fungus overwinters in infected cull tubers or seed tubers and initially develops inside the new foliage grown from infected tubers. Temperatures of 12°C–20°C, coupled with foliar wetness for a few hours, could cause sporulation of the fungus from the stomata of infected plants, which could further blow to infect healthy wet foliage. A small pool of infected plants can infest a whole field if uncontrolled.

A2 is a new, more aggressive strain of late blight with many races that have high levels of resistance to Ridomil. The old A1 strain has also developed resistance to Ridomil. Use protective fungicides (see Table 5–46, *Potato Disease Control Recommendations,* on page 111) and keep all foliage and newly formed leaves covered. Bury cull piles or control cull pile top growth. Scout fields twice a week and pull and bag the first infected plants seen. Mark these areas with a flag and recheck.

Create a good hill that ensures good tuber coverage. Disc in immediately or top-kill any late blight hot-spots. Tagged seed Elite or Foundation gives no guarantee it is not carrying late blight. Continuous copper sprays kill late blight spores in the soil that might otherwise be washed into the tubers.

The crop should be completely dead before harvest, so living spores are not sprinkled on tubers at harvest.

Note: Late blight spores can only survive on living tissue. Do not irrigate near the end of the season if new outbreaks of late blight are noticed.

Use one of the fungicides recommended in Table 5–46 on page 111.

Leak

Pythium leak is a fungal disease particularly troublesome in immature potatoes harvested under warm conditions. The typical symptom on infected tubers is a cream-coloured-to-black watery rot. Water usually drips from diseased tubers. The rotted flesh is clearly demarcated from healthy tissue by a dark boundary line. Tubers are infected through cut surfaces or bruises that occur during harvesting. Serious losses can occur also when tubers are handled roughly, and when crops are stored at high temperatures with poor ventilation. In addition, leak can be a problem on cut seed in the field.

The following management practices should reduce the incidence of leak:

- Minimize mechanical injury to the tubers during digging, grading and storage operations.
- Do not harvest when the weather is too hot.
- Cool tubers dug during warm weather immediately and increase air movement in the storage area.

The fungicides listed in Table 5–46 on page 111 should reduce the incidence of this disease.

Pink Rot

Pink rot is caused by a fungus that is related to the late blight fungus. Pink rot causes a soft, spongy rot on tubers. On exposure to the air, the infected flesh develops a pink colour. Internal rot usually begins at the stem end and is creamy or light brown. Wilt symptoms can occur on foliage.

The fungicides listed in Table 5–46 on page 111 should reduce the incidence of this disease.

Blackleg

This bacterial disease may be seed-borne and travel up into the shoot early on as the season progresses or it may develop in the vine as stalk rot and go down and infect the daughter tubers. Poor sanitation and seed cutting practices may increase the incidence of this disease. Weather conditions promote or retard blackleg. Where possible, use tolerant varieties that seldom get blackleg or stalk rot, and use higher generation seed.

Common Scab

Choose tolerant cultivars such as Superior, Cherokee, Onaway and Norland if appropriate. Avoid heavy applications of limestone. Where irrigation is available, maintain high soil moisture for about 4 weeks after tuber setting begins to minimize scab.

Recent research has shown that application of organic ammendments reduces the incidence of scab.

Powdery Scab

Powdery scab is only a problem in Northern Ontario. Plant Elite or Foundation seed. Plant in warm, well-drained soil. Do not plant in fields in which powdery scab has occurred in the last four years.

Bacterial Ring Rot (BRR)

Use tagged seed that had a BRR lab test. Practice complete cleanliness. (See the section *Sanitation* on page 106.)

TABLE 5–46.
Potato Disease Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Early and Late Blight Control Scheduled Protectant Program					
chlorothalonil	chloronitrile	Bravo 500 F	1.75–2.25 L	1	
mancozeb	dithiocarbamate	Dithane M-45	1.1–2.25 kg	1	
		Manzate DF	1.1–2.25 kg	1	
		Dithane DG	1.1–2.25 kg	1	
		Penncozeb 75 DF	1.1–2.25 kg	1	
metiram	dithiocarbamate	Polyram DF	1.1–2.25 kg	1	
propamocarb hydrochloride/ chlorothalanil	carbamate/ chloronitrile	Tattoo C	2.7 L	7	Apply prior to infection when weather conditions are conducive to late blight development. Repeat at 7–14 day intervals; maximum of 3 applications/season. When applying Tattoo C on the longer spray interval (14 days), alternate with a contact fungicide midway.
dimethomorph/ mancozeb	morpholine/ dithiocarbamate	Acrobat MZ	2.5 kg	14	Apply before disease symptoms are apparent; maximum of 3 applications/season.
Late Blight Control Only					
copper hydroxide	inorganic	Kocide 101 WP	1.1–3.4 kg	1	Copper aids in killing late blight spores that fall on the soil before they get washed in to infect tubers. If live spores are suspected at vine killing time, use Kocide after top killing as well. Kocide contains copper hydroxide or fixed copper, which does not cause phytotoxicity.
		Kocide DF	1.1–3.4 kg		
		Champion 50WP	1.1–2.5 kg combined with 1.75–2.25 kg mancozeb (80%)		
copper sulphate	inorganic	Copper 53W	5.5 kg	1	Copper sulphate can cause phytotoxicity especially under hot and humid conditions. Apply close to vine killing time to kill spores of the late blight fungus.
copper oxychloride	inorganic	Copper spray	4 kg	1	
cymoxanil	acetamide	Curzate 60 DF	225 g	8	Mix with Manzate 200 DF at 1.6 kg/ha. Do not enter fields within 24 hours. If seed infection is suspected, spray at 95% crop emergence.
***Pythium* Leak and Pink Rot**					
metalaxyl/ mancozeb	acylamine/ dithiocarbamate	Ridomil Gold MZ 68WP	2.5 kg		Mancozeb, the protectant fungicide in this mixture, should also provide protection against early and late blight. Do not use more than 3 times per season.
metalaxyl-chlorothalonil	acylamine/ chloronitrile	Ridomil/Bravo Twin Pak 240/500 F	1jug/1.4 L/ha		Do not use more than 3 times per season.

Spindle Tuber

This disease has been almost eliminated completely by lab testing. Use tagged seed in Elite classes.

Leaf-Roll Virus and Net Necrosis

Aphids may transmit potato leaf-roll from an infected potato plant to a clean potato plant during the season. In some varieties, this causes the newly infected plant to "net" the flesh of its daughter tubers. Russet Burbank is quite susceptible to this; Shepody is slightly susceptible. Control aphids by scouting fields and spraying. Use varieties resistant to net necrosis. Plant tagged seed indicating low or absent levels of this disease.

Pink Eye

Pink eye is caused by the bacterium *Pseudomonas fluorescens*, which is usually found in the soil. Pink eye is characterized by skin-deep, pinkish blotches near the eyes of the apex. The skin of affected tubers dries and cracks easily. Internal reddish-brown to black discoloration, cavities and soft rot are often associated with severe pink eye. The disease appears late in the growing season under conditions of high soil moisture. The bacterium requires high humidity to infect the tubers through the lenticels.

If the storage area is properly ventilated, the discoloured tissues dry out, turn light brown and become wrinkled and cracked. If the storage temperature is higher than 7°C and humidity is high, pink eye can spread to other tubers through wounds and lenticels. If there is not

enough air circulation, the affected areas may break into water-soaked brown lesions. **Increase air flow through the pile to promote drying of pink eye lesions.**

Field Control

There is no chemical control available to reduce the incidence of pink eye in the field. Pink eye is often associated with *Verticillium* and *Rhizoctonia* and good control of these fungal diseases will reduce the incidence of pink eye.

Insect Management

Wireworm, Cutworm and White Grub

See the sections *Cutworms* on page 16 and *Wireworms* and *White Grubs* on page 17.

Colorado Potato Beetle (CPB)

This insect has developed resistance to most of the insecticides registered for its control.

Resistance Management

Repeated use of any insecticide is the quickest way to establish resistance in pest populations.

The less a chemical is used, the longer it will take for a given insect to develop serious resistance to that material. In any insect species, individuals resistant to an insecticide are present in the population, even before the insecticide has been applied in the field. The exact frequency of resistant individuals is not known, but it is thought to be low, between 1 in a million to 1 in a billion individuals.

The Colorado potato beetle has demonstrated a tremendous ability to develop resistance to insecticides, which might indicate that the frequency of resistant individuals is at the higher end of this range.

Successive applications of an insecticide will reduce the populations of susceptible CPB, but will allow resistant individuals to increase in numbers and to mate, transferring resistance genes to their offspring.

To delay the development of resistance in CPB populations, rotate fields, use plastic-lined ditches, propane flamers and transgenic varieties.

Crop Rotation When fields are rotated, beetles must walk or fly from overwintering sites to newly planted fields. This takes time, and many beetles die before reaching the crop. This results in lower beetle populations than in non-rotated fields.

Plastic-lined trenches with steep sides These ditches trap emerging adults as they walk towards the potato crop from overwintering sites.

Propane flamers Flamers may be used on border rows or whole fields until the crop is 15 cm high.

Transgenic potatoes Potato varieties that have the Bt gene incorporated into the plants are not colonized by CPB, therefore no chemical control is required to control this pest during the growing season. Transgenic Superior, Atlantic, Shepody and Russet Burbank are registered in Ontario.

Insect Scouting

Regular field scouting provides accurate information on the pests present, their level of infestation and distribution in the field. This information allows the grower to apply insecticides only when strictly necessary ar 1 not on a regular basis.

Timing the sprays results in economic savings and better control of insects. For example, small CPB larvae are much easier to control than adult beetles or large larvae. Growers can reduce the number of insecticide sprays during the season by using these alternative methods.

Soil Treatments

One treatment with imidacloprid (Admire) (chloronicotinyl group) applied in-furrow over the seed piece can be used or one treatment with either phorate (Thimet) or disulfoton (Di-Syston) is an option in areas where the CPB has not developed resistance to these granular organophosphate insecticides. They are applied in the furrow at planting time for main crop and seed potatoes only. Do not dig potatoes within 90 days of application. These chemicals are extremely toxic; carefully follow all precautions on the label. See Table 5–47, *Potato Insect Control Recommendations,* on page 113, for recommendations.

Foliar sprays

Dip tests are recommended before spraying any insecticide because of the high levels of resistance found in CPB populations. Dip tests are very effective in determining which insecticide should provide the best control in your fields. See Table 5–47 on page 113 for recommendations.

For more information, consult the OMAFRA Factsheet *Colorado Potato Beetle Dip Test: On Farm Test To Determine Resistance to Pesticides,* Order No. 92-028.

TABLE 5–47.
Potato Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Colorado Potato Beetle					
Soil Treatments					
imidacloprid	chloronicotinyl	Admire 240 F	7.5 –12.0 mL		Per 100 metres of row.
			0.85–1.3 L		Based on 90-cm row spacing.
phorate	organophosphate	Thimet 15 G	14.5–22.4 kg	90	Use the higher rate on heavy silt or clay loam soils. Do not use on muck soils.
disulfoton	organophosphate	Di-Syston 15G	15–22.5 kg	90	Use the high rate on clay and muck soil. To reduce the possibility of groundwater contamination, alternate soil insecticides each year. For late-season control, apply an appropriate foliar material.
Foliar Sprays					
bacillus thuringiensis	bacterial	Novodor FC	5.0–8.0 L	1	For 1st and early 2nd instar Colorado beetle larvae only; other stages and other insects not controlled. Field scouting is essential for timing the sprays.
imidacloprid	chloronicotinyl	Admire 240 F	200 mL	7	Not more than 2 foliar applications/season. DO NOT use foliar Admire on a field where even a part (e.g., border rows) of the field has been treated with in-furrow Admire.
azinphos-methyl	organophosphate	Guthion 240 SC	1.75 L	7	Seven days between applications, maximum of 3 applications per season. Minimum period for re-entry is 48 hours.
		Sniper 240 E	1.75 L	7	Minimum period for re-entry is 48 hours.
		Sniper 50 W Clean Pak	0.85 kg	7	
naled	organophosphate	Dibrom EC	1.1 L	4	
cypermethrin	pyrethroid	Ripcord 400 EC	62.5–125 mL	7	
		Cymbush 250 EC	140 mL	7	
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83–125 mL	7	Use the higher rate for larger instars and higher populations of larvae. Three applications per year at the 83 mL rate or 2 applications per year at the 125 mL rate are permitted. Do not exceed 250 mL per season. Minimum period for re-entry is 24 hours.
oxamyl	carbamate	Vydate L	2.3–3.0 L	7	Minimum period for re-entry is 24 hours.
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.0–1.5 kg	1	
		Thiodan 4 EC	1.5–2.0 L	1	2.0 L only for TPB.
		Thionex 400 EC	1.5 L	1	
Potato Leafhopper					
azinphos-methyl	organophosphate	Guthion 240 SC	2.25–3.5 L	7	Minimum period for re-entry is 48 hours.
		Sniper 240 E	2.25–3.5 L	7	
		Sniper 50 W Clean Pak	1.1–1.75 kg	7	
naled	organophosphate	Dibrom EC	1.1 L	4	
dimethoate	organophosphate	Cygon 480 E	0.55–1.1 L	7	
		Lagon 480 E	0.55–1.1 L	7	
acephate	organophosphate	Orthene 75 SP	0.75–1.1 kg	21	Do not apply more than 4 times per season.
cypermethrin	pyrethroid	Ripcord 400 EC	62.5–125 mL	7	
		Cymbush 250 EC	140 mL	7	
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	7	Minimum period for re-entry is 24 hours.
deltamethrin	pyrethroid	Decis 5.0 EC	100–150 mL	3	
permethrin	pyrethroid	Pounce 384 EC	180–260 mL	1	
oxamyl	carbamate	Vydate L	2.3–3.0 L	7	Minimum period for re-entry is 24 hours.
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.0–1.5 kg	1	
		Thiodan 4 EC	1.5–2.0 L	1	
		Thionex 400 EC	1.5 L	1	

TABLE 5–47.
Potato Insect Control Recommendations (Continued)

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Flea Beetle					
azinphos-methyl	organophosphate	Guthion 240 SC	2.25–3.5 L	7	Minimum period for re-entry is 48 hours.
		Sniper 240 E	2.25–3.5 L	7	
		Sniper 50 W Clean Pak	1.1–1.75 kg	7	
naled	organophosphate	Dibrom EC	1.1 L	4	
acephate	organophosphate	Orthene 75 SP	0.75–1.1 kg	21	Do not apply more than 4 times per season.
chlorpyrifos	organophosphate	Lorsban 4E	1.0 L	7	
		Pyrinex 480 EC	1.0 L	7	
cypermethrin	pyrethroid	Ripcord 400 EC	62.5–125 mL	7	
		Cymbush 250 EC	140 mL	7	
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	7	Minimum period for re-entry is 24 hours.
deltamethrin	pyrethroid	Decis 5.0 EC	100–150 mL	3	
permethrin	pyrethroid	Pounce 384 EC	180–260 mL	1	
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.0–1.5 kg	1	
		Thiodan 4 EC	1.5–2.0 L	1	
		Thionex 400 EC	1.5 L	1	
Aphids – Green peach aphids are the most common species found on potatoes. Some aphids are showing tolerance to some materials when colonizing (bearing young), consult your pesticide dealer or crop specialist for best choice of material.					
methamidophos	organophosphate	Monitor 480 EC	1.75–2.25 L	14	Monitor also kills leafhoppers, tarnished plant bug and flea beetles. It can be effective against Colorado potato beetle in areas where this insect has not developed resistance to this insecticide yet. Minimum period for re-entry is 48 hours.
dimethoate	organophosphate	Cygon 480 E	550 mL–1.1 L	7	
		Lagon 480 E	550 mL–1.1 L	7	
acephate	organophosphate	Orthene 75SP	0.75–1.1 kg	21	Green peach and potato aphids only. Do not apply more than 4 times per season.
pirimicarb	carbamate	Pirimor 50 DF	450–550 g	3	
oxamyl	carbamate	Vydate L	2.3–3.0 L	7	Green peach and potato aphids only. Minimum period for re-entry is 24 hours.
Tarnished Plant Bug					
azinphos-methyl	organophosphate	Guthion 240 SC	2.25–3.5 L	7	Minimum period for re-entry is 48 hours.
		Sniper 240 E	2.25–3.5 L	7	
		Sniper 50 W Clean Pak	1.1–1.75 kg	7	
dimethoate	organophosphate	Lagon 480 E	0.55–1.1 L	7	
acephate	organophosphate	Orthene 75 SP	0.75–1.1 kg	21	Do not apply more than 4 times per season.
chlorpyrifos	organophosphate	Lorsban 4 E	1.0 L	7	
		Pyrinex 480 EC	1.0 L	7	
cypermethrin	pyrethroid	Ripcord 400 EC	125 mL	7	
		Cymbush 250 EC	200 mL	7	
deltamethrin	pyrethroid	Decis 5.0 EC	100–150 mL	3	
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	7	Minimum period for re-entry is 24 hours.
permethrin	pyrethroid	Pounce 384 EC	180–260 mL	1	
oxamyl	carbamate	Vydate L	2.3–3.0 L	7	Minimum period for re-entry is 24 hours.
endosulfan	chlorinated cyclodiene	Thiodan 50WP	1.5 kg	1	
		Thiodan 4 EC	2.0 L	1	
		Thionex 400 EC	2.0 L	1	
Late-Season Cutworm					
chlorpyrifos	organophosphate	Lorsban 4 E	1.2–2.4 L	7	
		Pyrinex 480 EC	1.2 –2.4 L	7	
cypermethrin	pyrethroid	Ripcord 400 EC	175 mL	7	

Potato Leafhopper, Flea Beetle

If monitoring indicates a need, see Table 5–47, *Potato Insect Control Recommendations*, on page 113, for control recommendations.

Aphid

If monitoring indicates a need for green peach, potato or buckthorn aphids control, apply one of the insecticides recommended in Table 5–47 on page 113.

Tarnished Plant Bug

If monitoring indicates a need, apply one of the foliar sprays recommended in Table 5–47 on page 113.

Late-Season Cutworms

These pests have caused both tuber and foliage damage. Control of these cutworms can only be obtained when they are active above the soil surface prior to tuber migration and feeding. Thorough penetration of dense foliage is required for optimum control. Consult your crop specialist regarding insect adult flights to aid in spray-timing decisions. Apply one of the pesticides recommended in Table 5–47 on page 113.

Nematode Management

See the section *Nematodes* on page 17 for control recommendations.

Other Problems

Sprout Inhibition

After completion of a rest period, potatoes sprout readily. Potatoes treated with chemical sprout inhibitors can be stored at 10°C or higher without sprouting.

Field-Applied

Maleic hydrazide is a plant growth regulator, applied as a single application in the field (for example, Royal MH 60 SG 5.65 kg in 300 L of water) to control sprouting of potatoes in storage. It should be applied in a manner that insures complete and uniform coverage. Timing is important. Recent research has shown that too early an application on some cultivars may result in reduced potato size and phytotoxicity.

Consult manufacturer's recommendations for more detailed information on both rates and timing. Time of application may occur as early as 2–3 weeks past full bloom. Only apply to plants that are still green and free from insects, disease and other damage.

Once in storage, tubers treated with maleic hydrazide will not affect seed potatoes stored in the same storage, or those stored in crates formerly used for the storage of maleic hydrazide-treated tubers.

Storage-Applied

CIPC is another chemical that is widely used for sprout inhibition.

Apply it in storage as a dip, spray or aerosol just before sprouting starts. Potato tubers may be treated with this chemical before packaging for market. Do not apply CIPC at harvest time.

Application as a gas to storage bins must be performed by a licensed applicator.

To use CIPC in packing lines, prepare 1 L of Sprout Nip EC in 35 L of water, stir to make an emulsion and use 1 L of this emulsion per tonne of potatoes.

Do not use either of these treatments on potatoes grown for seed. Do not store seed potatoes in the same storage with CIPC-treated tubers, or in crates that were in the storage when CIPC was applied.

Vine Killing

Vine killing is especially important to seed growers as an early kill controls tuber size and reduces the spread of virus diseases by aphids.

Chemical vine killers are not recommended for early potatoes because they limit the yield, size and dry-matter content without reducing skinning.

However, where it is necessary to control size to reduce hollow heart, chemical vine killing may be of value at times for early potato crops. Use Reglone (Diquat) as follows:

a) Heavy green top growth and weeds – 4.25 L/ha.
b) Medium top growth or crop beginning to mature – 2–2.75 L/ha.
c) Split application – Apply 2.0–2.5 L/ha followed by 1.5 L/ha in 5–6 days.

Apply in a least 600 L/ha of clean water (muddy water may inactivate Reglone). Allow 14–21 days after application until harvest to allow proper vine desiccation and tuber skin set.

Note: Over-application or conditions that lead to very rapid kill may cause darkening at the stem end of the tuber.

Aircraft application of Reglone is not recommended. Ensure that no drift occurs from any of these materials to adjacent crops, because the residue of these compounds on other crops may result in their seizure.

The product Ignite (glufosinate ammonium) is labeled as a dessicant on table stock and processing potatoes. **Do not apply to potatoes grown for seed.** Apply 3.0 L per ha in 110–220 L water per hectare. Use the higher rate of water when the crop canopy is dense. Apply to potato vines 14–21 days prior to harvest.

Within 2–4 days of applying Ignite, symptoms of dessication will appear.

The product "Des-I-Cate" (endothall) is also labeled. For light vine growth, apply 17–22 L; for medium to heavy vine growth, apply 22 L. Use the higher rate during cool (less than 21°C), cloudy weather.

Apply to potato vines 10–14 days prior to harvest.

The use of roto-beaters is not recommended except where dead vines or weeds are a hindrance to the digger.

Storage

Store seed tubers separately from tablestock potatoes, in a disinfected storage area. Do not store seed potatoes in the same storage area with CIPC-treated tubers.

Healing of cuts and bruises is most rapid at a tuber temperature of 15°C–21°C. It is desirable to provide this temperature for 2–3 weeks at the beginning of the storage period. After this, the temperature should be lowered to 5°C if potatoes are intended for tablestock or seed. Potatoes intended for processing should be maintained, preferably, at 10°C and should never be subjected to temperatures below 5°C. It will be necessary to use a sprout inhibitor if potatoes are to be stored at 10°C for an extended period.

The relative humidity in the storage should be as high as possible without causing condensation of moisture on tubers and the storage structure. However, if soft rot is prevalent or if the tubers are wet when first put into storage, the humidity should be kept down until the tubers are dry.

For more information, see the section *Storage* on page 46.

Visit the vegetable page on the OMAFRA Web site at http://www.gov.on.ca/OMAFRA/english/crops/hort/vegetable.html

RADISH

Cultivars

The cultivars listed in Table 5–48, *Radish Cultivars*, right, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. In some cases, other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under Ontario growing conditions. Varieties of crops change frequently; check with a range of seed company representatives for additional recommendations and variety descriptions.

Cultivars or strains with globe-shaped roots, with entirely red skins and with leaves that are short-to-medium in length are the most popular. Medium-top strains are preferable for early spring crops, and short-top strains preferable during the longer-day period.

Radish, a cool-season crop, is adversely affected by hot, dry weather and remains in prime condition for only a few days. To be mild, tender and attractive, it must be grown rapidly with plenty of moisture. If growth is reduced, the roots become hot, tough and pithy. Under medium-to-short day length, roots are normally well-shaped and tops relatively small. Under long days (15 hours), roots are misshaped and tops are long and usually produce seed stalks.

Seed Treatment

See the section *Chemical Seed Treatment* on page 11.

Seeding and Spacing

Seeding Plant 11–17 kg seed/ha. For machine harvesting, use 22–34 kg/ha.

Spacing Plant radish in rows 20–30 cm apart, with 40–50 plants per metre of row. For machine harvesting, space rows 10–15 cm apart.

Spring Crop

The seed may be sown in the spring as soon as the soil is workable. Spring frosts or even heavy snowfalls usually do not injure the crop seriously after the plants have emerged. Under favourable weather conditions, radish seedlings appear above ground 2 or 3 days after sowing. Sowing at intervals in the spring will provide a continuous harvest.

Summer and Fall Crop

Radishes are grown successfully on muck soils throughout the growing season, because such soils are usually well supplied with moisture and provide a cool growing medium. Only large-sized seed of the short-to-medium-foliage cultivars or strains of radishes should be used. On mineral soils, radishes are successfully grown, however heat and drought stresses may be more severe, causing misshapen radishes and excessive top growth in some varieties.

TABLE 5–48. Radish Cultivars

Main Crop	Jumbo	Bunching
Fuego	Champion	Revoso
Red Cheriette	Red Crunchy	Red Fortress
Champion	Scarlet Globe	Red Baron
Cherry Belle	Special	Red Silk
	Snow Belle (White)	

Fertilizer

Nitrogen

On mineral soils, apply up to 60 kg N/ha. On muck soils, apply 55 kg N/ha. If manure is applied or legume sod is plowed down, reduce the nitrogen application. See Table 3–10 and Table 3–11 on page 28 and page 29.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. See Table 3–5, Table 3–6 and Table 3–7 on page 24 and page 25.

Disease Management

Damping-Off

Use seed treated with thiram (dithiocarbamate group) seed protectant. Do not plant seed too deeply and avoid excessive irrigation.

Rhizoctonia

Rhizoctonia on radish can cause severe losses. This fungus attacks the feeder roots and storage root. Loss of yield can occur as a result of interference with nutritional uptake or more likely as a result of deformed and blemished storage roots. Stems and cotyledons can also be damaged.

Rhizoctonia prefers cooler, wetter soils and usually appears in the spring and fall. In the storage root, the disease can be identified as vertical cracks in large areas that deform the root. The smaller feeder roots will show brown areas.

This disease may also take the form of "scurf" on the storage root. This appears as a black netting and can be washed off in water. Stems that are infected will develop a dark brown lesion, shrink and become tough and woody, a typical "wire stem" symptom.

At the present time, there is no effective chemical control of this disease on radishes in Ontario. Cultural practices that increase soil temperature and decrease soil moisture may provide some relief if the soil inoculum level is not

TABLE 5–49.
Radish Insect Control Recommendations

Common Name	Group	Trade Name	Rate	Days to Harvest	Notes
Cabbage Maggot					
chlorpyrifos	organophosphate	Lorsban 4E	85 mL/ha	21	Per 1,000 m of row in 380 L water.
		Pyrinex 480 EC	85 mL/ha	21	
Flea Beetles					
permethrin	pyrethroid	Pounce 384 EC	175 mL/ha	2	
carbaryl	carbamate	Sevin XLR Li	1.25–2.5 L/ha	7	
Aphid					
diazinon	organophosphate	Diazinon 50 W	1.1 kg/ha	10	Control of aphids with these products has been inconsistent in many areas.
		Diazinon 500 EC	1.1 L/ha	10	
		DZN 600 EW	0.915 L/ha	10	
malathion	organophosphate	Malathion 500 E	1.1–2.75 L/ha	7	

too high. Rotating out of crucifers for 2–3 years should reduce the incidence of this disease.

Fusarium Wilt (Yellows)

Fusarium yellows or wilt of radish is a soil-borne disease that can seriously affect radishes, especially during warm periods. If the disease attacks the plants when they are small, the leaves will turn yellow and then rapidly turn brown. In some cases, the small radish plants will completely die and the symptoms may be easily confused with *Rhizoctonia* diseases. When the disease attacks more mature radish roots, the plants will appear severely weakened, and the root may become spongy. When cut open, the vascular tissue will be yellowish-brown and sometimes the centre is hollow.

Some varieties of radish have resistance to the disease, which is the only control strategy currently available.

Downy Mildew

Downy mildew causes damage to radishes especially during cool, damp weather. Symptoms appear as yellow spots on the upper surfaces and grayish-white growth on the undersides of leaves. The disease can also attack the root, causing dark discoloured areas extending down the root from the crown. Infected roots may split or be invaded by secondary rot organisms.

Black Root

This is another soil-borne disease that is favoured by warm, moist soil conditions. When the disease attacks the radish root, the exterior and interior of the radish will blacken, and often the tops will be stunted. The rot normally begins as a dry rot, but is often complicated by the invasion of secondary bacterial rots.

Avoid spreading infected soil between field areas, work crop residues well into the soil and practise rotations of at least four years. Some radish varieties may have resistance to the disease.

Scab

This soil-borne bacterial disease causes scale-like spots that may enlarge to 1–2 cm. Edges of spots are usually raised, and lesions may become infected with secondary rots. Rotations with grains is partially effective. The disease is more severe in lighter, dry soils.

Other Diseases

Radishes may also be infected by other diseases such as clubroot, *Alternaria* spot, white rust and viruses, however these diseases are generally of low incidence in Ontario except on Asian-type radishes. Consult the section *Specialty Vegetables* on page 124 for more information.

Insect Management

Cabbage Maggot

Using one of the insecticides recommended in Table 5–49, *Radish Insect Control Recommendations*, above, drench with seed at planting time. Later plantings usually require less protection.

Flea Beetle

To limit the development of resistance, the insecticides listed in Table 5–49, above, should be used alternately and applied when monitoring indicates a need.

Aphid

If monitoring indicates a need, spray with one of the insecticides recommended in Table 5–49, above.

Note: The booklet *IPM for Crucifers in Ontario*, Order No. 701, contains a section on radish illustrating many of the common diseases and insect pests.

RHUBARB

Cultivars

See Table 5–50, *Rhubarb Cultivars*, right, for recommended cultivars and their descriptions.

Spacing

Plant in rows 75 cm apart, with plants 75 cm apart in the row (17,220 plants/ha). To produce roots for forcing, spacing in the field may be adjusted to 90 cm between rows and plants (11,950 plants/ha) without any loss of yield or quality.

Plant Selection

A number of viral and other diseases reduce plant vigour and yield, both in the field and in the forcing shed. Plants with vigorous growth should be marked during June and left in the field until the following spring, then dug up and used as planting stock. Discard the remainder.

Flower-Stalk Removal

Flower stalks should be cut out while they are still small, and before the flowers open. This can conveniently be done at the same time as harvesting a crop for processing, but in crops grown for early fresh market or for forcing, a separate operation will be necessary.

Site Selection

Rhubarb grows best on loam or heavier cold-bottom but well-drained soil. Variety Sutton grows on lighter soils with irrigation.

Fertilizer

Nitrogen

Apply up to 280 kg N/ha for rhubarb to be forced and only up to 200 kg N/ha (split application) for field production.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 3–5, Table 3–6 and Table 3–7 on page 24 and page 25).

Application

Preplanting Plow under 45–90 tonnes/ha of manure in the fall. Broadcast and cultivate in 100 kg N/ha, with all of the phosphate and potash required, before planting.

Annually Just before the buds break each spring, apply 100 kg N/ha, with the phosphate and potash required (based on a soil test) as a broadcast application, or preferably as a side-dressing at a 10-cm depth. Immediately after pulling the crop for processing, apply broadcast 100 kg N/ha. Rhubarb to be forced should receive 180 kg of N/ha in July giving a total annual N requirement of 280 kg/ha.

Irrigation As much as 100 kg N/ha may be applied through the irrigation system after pulling or in July for plants that are to be used for forcing.

Note: The use of gibberellic acid (Activol GA) is recommended for rhubarb forcing. Consult label for details.

TABLE 5–50.
Rhubarb Cultivars

Cultivar	Variety
Outdoor	
Sutton	Red/green skin colour, green-fleshed variety, grows 100 cm tall, high producer with 20,000–40,000 kg/ha, has some seed stalks. Tart and high yield, often used for processing. Season mid-May through mid-June.
Valentine	Red skin and flesh, 75 cm tall, produces 10,000–30,000 kg/ha, few seed stalks. Harvest through June into early July.
Macdonald	Red skin, green flesh, grows 75 cm tall, produces 10,000–30,000 kg/ha, some seed stalks. June harvest season.
German Wine	Red skin, green flesh, approximately 90 cm tall, 15,000–35,000 kg/ha, some seed stalks. June harvest season.
Forcing	
Victoria Sutton	Will produce 1.5–2.5 kg of reddish pink stalks per plant between early January and mid-May.

Disease Management

Crown Rot and Virus Disease

See the section *Plant Selection*, left. Remove and destroy diseased plants. Only vigorous, normal plants should be used for propagation.

Insect Management

Potato Stem Borer

Eggs overwinter in grasses and by mid-summer the larvae move to larger-stalked plants such as corn, potatoes, tomatoes and rhubarb. Grassy weed control in and around rhubarb plantings may be helpful.

Rhubarb Curculio

Destroy dock weeds near the rhubarb planting.

Nematode Management

See the section *Nematodes* on page 17.

RUTABAGA

Cultivars

The recommended rutabaga cultivars are the Laurentian strains.

Seed Treatment

Buy sized, registered seed with a high percentage germination and vigour. To control seed decay and damping-off, treat seed before planting with a seed-protectant such as thiram (dithiocarbamate group) (Thiram 75 WP) or carbathiin/thiram/lindane (oxathiin, dithiocarbamate, polychlorocycloalkane groups) (Vitavax RS FL). To control black rot, seed may be treated with streptomycin (antibiotic group). Follow the manufacturer's directions on the label.

Seeding and Spacing

The optimum soil temperature for germination is from 16°C–29°C. Sowings made after mid-June are more vulnerable to virus infection. Use up to 500 g of seed/ha. Plant seed, up to 1.5 cm deep. Use seeders that space the seeds at known intervals, and use seed that has been precisely sized. This will eliminate or facilitate thinning and produce a highly uniform crop. Where thinning is required, do so when plants are 4–8 cm high; space plants 13–15 cm apart in the row. Plant rows from 60–90 cm apart.

Fertilizer

Nitrogen

Apply up to 35 kg N/ha. Manure may be used in the rotation at the rate of 18–22 t/ha but should be applied at least a year before the rutabaga crop is grown. If manure is applied or legume sod is plowed down, reduce the nitrogen application. (See Table 3–10 and Table 3–11 on page 28 and page 29.)

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 3–5, Table 3–6 and Table 3–7 on page 24 and page 25.)

Secondary and Micronutrients

Boron

Water-core or brown heart may be caused by boron deficiency and first appears in young, enlarging roots as firm, brownish, water-soaked patches. These may increase in size until almost the whole rutabaga root is affected. Severely affected rutabagas may turn punky inside during storage.

Boron can be applied to the soil before sowing. The necessary quantity of boron can be mixed with the fertilizer that is applied before planting. Boron-enriched fertilizer should be applied as uniformly as possible. Generally, foliar applications of Solubor are as effective as larger amounts applied to the soil. The first foliar application should be made when the roots of the plants are about 1.5–2.5 cm in diameter. The second and third applications may be applied at 10- to 14-day intervals after the first spray. Do not combine pesticides with boron sprays unless the label specifies compatibility. Excessive applications of boron will often adversely affect the succeeding crop in the rotation (e.g., soybeans, snap beans, white beans and small grains). Consult the section *Boron* on page 27 and Table 3–10 on page 28.

Disease Management

Damping-Off

See the section *Seed Treatment* on page 11 and *Damping-Off of Seedlings* on page 12.

Black Rot and Blackleg

See the section *Seed Treatment* on page 11. Do not plant rutabagas, canola, kale, cabbage and other crucifers more than once in 4 or 5 years on the same land. Do not apply manure containing rutabaga refuse or diseased rutabagas on land intended for rutabagas. Do not work in the field when plants are wet. Never store diseased rutabagas. Clean out and disinfect the storage area each spring.

Club Root

Use a crop rotation with non-cruciferous crops. Avoid fields known to be infested. See the section *Cole Crops* on page 58. (Note comment regarding calcitic lime).

Mosaic Virus

Losses from turnip mosaic virus are especially heavy in plantings sown after mid-June. Volunteer rutabagas and winter rapeseed are the main overwintering sources of the virus. Aphids transmit the virus to the rutabaga crop. Aphicides do not prevent the spread of the virus. For virus control recommendations, consult the OMAFRA Factsheet, *Turnip Mosaic Virus (TuMV) of Rutabaga*, Order No. 88-091. Applications of mineral oil (Superior 70 Oil) deter the feeding of aphids, which spread TuMv. If monitoring indicates a need, apply as recommended in Table 5–51, *Rutabaga Disease Control Recommendations*, on page 121.

Powdery Mildew

The cultivar Laurentian is very susceptible to powdery mildew. The fungus spreads by means of conidia

TABLE 5–51.
Rutabaga Disease Control Recommendations

Common Name	Group	Trade Name	Rate	Days to Harvest	Notes
Mosaic Virus					
mineral oil	N/A	Superior 70 Oil	11 L/ha in 600–1,100 L water/ha	21	Do not apply mineral oil in direct sunlight. Aphid feeding deterrent only.
Powdery Mildew					
propiconazole	triazole	Topas 250 E	400 mL in 200 L of water	21	A second application may be made 20 days after the first.
sulphur	inorganic	Micro-Niasul W	6.8 kg in 675–1,125 L of water	0	Water volume depends on the stage of growth.
		Microscopic Sulphur WP	6.8 kg in 675–1,125 L of water	0	Water volume depends on the stage of growth.

(spores), which are carried long distances by wind. Disease spread occurs rapidly during hot, dry weather. Control must be initiated at the first appearance of symptoms, which are white, circular or star-shaped spots on older leaves and stems. Use the fungicides recommended in Table 5–51, *Rutabaga Disease Control Recommendations*, above.

When using sulphur, thorough spray coverage of both upper and lower leaf surfaces is essential for powdery mildew suppression. This may require application at higher spray pressures than normally used. Apply sulphur weekly but use no more than 5 applications per season. This product is not compatible with Superior Oil.

Insect Management

Root Maggots

Cabbage maggots overwinter as pupae in the soil in fields where they developed during the previous season. The adult flies emerge in early May and there are three (occasionally four) generations throughout the season. Practise crop rotation and plant early rutabagas as far as possible away from fields used for rutabagas or cole crops last year. Do not grow early and late rutabagas in the same field or near winter rapeseed, early broccoli, cabbage or cauliflower.

There are three periods of maggot damage related to the emergence of the three generations of flies: early in the season (prior to mid-June), during early July and late in the season (after mid-August). Therefore, control of root maggots can be timed to coincide with the start of egg-laying activity of each generation of adults. Monitoring programs for cabbage maggot may help with spray timing.

Only a few insecticides are effective. Each of these is highly toxic, and applicators must take full safety precautions when using and storing these chemicals (see the section *Reducing Exposure* on page 4). Safe disposal of empty bags and containers is equally important.

Treatment at Planting

Use one of the granular insecticides recommended in Table 5–52, *Rutabaga Insect Control Recommendations*, on page 122, in a 10–15 cm band at planting time only. Incorporate into the soil according to label instructions.

Treatment After Planting

If no granular treatment is used at seeding, apply a drench spray using one of the sprays recommended in Table 5–52 on page 122.

Subsequent Treatments

Regardless of whether the granular or drench procedure is used for the first application, follow with drench sprays as listed in Table 5–52 or time applications according to emergence of second or third generation maggot flies. Observe the days-to-harvest interval.

Flea Beetles

These insects can be controlled only in the adult beetle stage. There is no control for larvae established in roots. A spray should be applied as soon as the beetles appear in the field. Because beetles may migrate into the field over several weeks, a number of applications may be required.

If insecticide drenches are used to control root maggots, flea beetles may also be controlled. If drenches are not applied before seedling emergence and seedlings are attacked when they come up, or if beetles are numerous during the growing season, spray with one of the materials recommended in Table 5–52 on page 122. To limit the development of resistance, alternate between insecticide groups for each application.

TABLE 5–52.
Rutabaga Insect Control Recommendations

Common Name	Group	Trade Name	Rate	Days to Harvest	Notes
Root Maggot					
Treatment at Planting					
terbufos	organophosphate	Counter 15 G	1.5 kg/1,000 m of row		
chlorpyrifos	organophosphate	Lorsban 15 G	0.6–1.0 kg/1,000 m of row		
		Pyrifos 15 G	0.6–1.0 kg/1,000 m of row		
Treatment After Planting					
chlorpyrifos	organophosphate	Lorsban 4E	210 mL/125 L of water/ 1,000 m of row	28	Apply on soil, 10 cm on each side of the plant 10 days after seeding.
Subsequent Treatment					
chlorpyrifos	organophosphate	Lorsban 4E	210 mL/125 L of water/ 1,000 m of row	28	Apply on soil, 10 cm on each side of plants 28, 49, and 70 days after seeding. Use no more than 4 applications per season.
Flea Beetle					
carbaryl	carbamate	Sevin XLR Li	1.25–2.5 L	7	
permethrin	pyrethroid	Pounce 384 EC	180 mL	before 8-leaf stage	
cypermethrin	pyrethroid	Cymbush 250 EC	200 mL	21	
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	2.0 L	45	Use no more than 2 applications per season.
		Thionex 400 EC	2.0 L	45	Use no more than 2 applications per season.
Aphid					
dimethoate	organophosphate	Cygon 480 E	0.7 L	7	
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	2.0 L	45	Use no more than 2 applications per season.
		Thionex 400 EC	2.0 L	45	Use no more than 2 applications per season.
Leaf-Eating Caterpillars					
bacillus thuringiensis	microbial	Dipel 2XDF	275–550 g	0	Use higher rates for looper control.
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	2.0 L	45	Use no more than 2 applications per season.
		Thionex 400 EC	2.0 L	45	Use no more than 2 applications per season.
Cutworm					
chlorpyrifos	organophosphate	Lorsban 4E	1.2–2.4 L	30	May be used at the rate of 2.4 L as a preplanting treatment. (Apply once at seedling stage (2–5 leaves), when damage first appears.)
		Pyrinex 480 EC	1.2–2.4 L	30	

Aphids

If monitoring indicates a threat to the crop, spray with one of the insecticides recommended in Table 5–52, above. These insecticides are not likely to be effective against aphids if combined with boron sprays. See also Table 5–51, *Rutabaga Disease Control Recommendations*, on page 121, under "Mosaic Virus."

Leaf-Eating Caterpillars

If cabbageworms, diamondback moth larvae, cabbage loopers, zebra caterpillars, etc., are numerous, spray with one of the insecticides recommended in Table 5–52, above.

Cutworm

See the section *Cutworms* on page 16. To control dark-sided cutworm, black cutworm, and red-backed cutworm, use one of the pesticides recommended in Table 5–52, above.

Nematode Management

See the section *Nematodes* on page 17 for control recommendations.

Note: The OMAFRA booklet *IPM for Crucifers in Ontario*, Order No. 701, provides a good summary of IPM for rutabagas in Ontario.

Post-Harvest

Harvesting and Washing

Avoid bruising. Damaged and bruised rutabagas are likely to rot and do not store well.

Dirty water contains large numbers of rot-causing organisms. To reduce loss from disease after waxing, change the water in the wash tank frequently or add fresh water continuously to keep water as clean as possible. Then rinse rutabagas with clean water and dry them as rapidly as possible before waxing or shipping. Trimming after washing helps reduce rot in waxed rutabagas. Calcium hypochlorite in the rinse water has shown to be effective in reducing losses after waxing.

Waxing

Rutabagas are normally hot-waxed just before being marketed. Waxing improves their appearance, keeps them clean, protects freshly trimmed surfaces from disease organisms and prevents undue moisture loss and shrinkage during the marketing period. Waxing is not recommended for rutabagas being held in storage. Immerse clean, dry rutabagas for one second in a "rutabaga/turnip" wax at 126°C and then pack as desired for market. Temperatures must be kept low after waxing as rutabagas can spoil within a few days at room temperature. Rutabaga wax is available at International Group Incorporated (IGI), 50 Salome Dr., Agincourt, Ontario (Tel. 416-293-4151). Ask for "turnip wax" — product code 2291.

Storage

Clean the storage area thoroughly in the spring. To disinfect the area, spray all surfaces with a mixture of 1 kg of copper sulfate (bluestone) and 2 kg of hydrated lime, dissolved in 50 litres of water. Add the lime last. Since this mixture is corrosive to metals, cover metal fixtures such as fans, electrical control equipment, etc., during the spraying operation. An alternative disinfectant spray is a 200 ppm solution of calcium hypochlorite. In addition, there are also other commercial disinfectants such as DCD available (see Table 4–10, *Proven Disinfectants*, on page 48). Check the labels and follow all cautions. Do not spread refuse from the storage area on land that may be used for rutabagas. Never put diseased rutabagas in storage. Disease-free rutabagas will keep up to 6 months if stored at 0°C and a relative humidity of 90–95%. Adequate ventilation and air movement throughout the storage area are necessary.

Before feeding rutabaga tops or trimmings to livestock, check pesticide labels for warnings.

Do not feed vegetables treated with endosulfan to livestock or poultry.

Visit the vegetable page on the OMAFRA Web site at http://www.gov.on.ca/OMAFRA/english/crops/hort/vegetable.html

SPECIALTY VEGETABLES

A variety of vegetables that are traditionally associated with regions outside of North America are grown in Ontario. Many of these vegetables are of Asian and Middle Eastern origin. These crops belong to a range of plant families including legumes, cole crops, cucurbits and others. Pest management strategies developed for other crops in Ontario may be helpful in these crops, since many of the pests and diseases are similar. There are also new and unique problems associated with these crops and the selection of pest control products available for such crops is limited.

Nomenclature

Many of the crops of Asian origin have different names depending upon the language used (Mandarin Chinese, Cantonese Chinese, Vietnamese, Korean or Japanese, for example). Table 5–53, *Specialty Vegetables*, on page 125, summarizes some of the crops grown in Ontario. The crop must be identified correctly for pest control to be effective.

For more information, consult the OMAFRA Factsheets *Asian Vegetables Grown in Ontario*, Order No. 98-033 and *Chinese Cabbage Production in Southern Ontario*, Order No. 98-067.

Fertilizer

Because of the wide range of specialty crops, a single fertilizer recommendation cannot be made, however, a fertility program based on a soil test can form the basis for good crop health. A proper balance of nitrogen, phosphorous and potassium as well as an understanding of the micronutrient requirements (zinc, boron, magnesium, manganese, copper, molybdenum, calcium, etc.) of each crop may be helpful. Experience from traditional Ontario cole crops and cucurbits will also be useful.

Disease Management

Growers should be aware that many of the diseases affecting these crops may be seed-borne. Ensure where possible, the seed is certified as disease-free or within acceptable guidelines. Hot water seed treatments may also be helpful. (See the section *Hot-Water Treatment* on page 11.)

Cultural practices can help growers reduce disease problems. Crop rotation of at least 3 years is recommended. To reduce bacterial diseases, avoid moving around in the field when it is wet and alter irrigation schedules. Use resistant varieties if available, control disease vectors such as aphids and remove weed hosts around the field. Roguing out virus-infected plants may also be helpful.

Some Common Diseases of Specialty Vegetables

Asian radish (lo bok, daikon, moo): turnip mosaic virus, downy mildew, *Alternaria* leaf blight

Nappa cabbage (siew choy, da bai cai, baechu): turnip mosaic virus, downy mildew, soft rot, *Alternaria* leaf spot, clubroot, *Pseudocercosporella* leaf spot

Bok choy, gai choy, yow choy, pak choy, gai lan, etc.: turnip mosaic virus, downy mildew, soft rot, clubroot, *Pseudocercosporella* leaf spot, *Alternaria* leaf blight

Cucurbits (fuzzy squash, bitter melon, winter melon): powdery mildew, mosaic viruses, bacterial wilt, angular leaf spot, scab, anthracnose

Currently, no fungicides are labeled for these crops, however, to reduce disease problems it is important to use treated seed, deep-plow crop residues into the soil, eliminate cull piles, rotate crops annually, remove weed hosts, reduce overhead irrigation and use healthy transplants grown in clean plug trays and sanitized greenhouses.

Insect Management

Aphids, Cutworms, Cabbage Looper, Diamondback Moth, Imported Cabbageworm, Tarnished Plant Bug, Cabbage Maggot

See Table 5–54, *Specialty Vegetables Insect Control Recommendations*, on page 126, for control recommendations.

For more information, consult the OMAFRA Factsheet *Tarnished Plant Bug Damage on Vegetable Crops in Ontario*, Order No. 98-025 and *IPM for Crucifers in Ontario*, Order No. 701.

Weed Management

Consult Chapter 6, *Weed Management for Vegetables* on page 141, for information on weed management.

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TABLE 5–53. Specialty Vegetables

English	Chinese	Korean	Japanese	Vietnamese	Latin
Edible amaranth (callaloo, tampala)	hinn choy (C) xian cai (M)	chambirum	hi yu na	rau den do	*Amaranth mangostanus* *A. gangeticus*
Asian water celery Water dropwort	shui qin (M)	minari	seri	cang nuoc rau can nuoc	*Oenanthe stolonifera*
Asparagus bean	dau guak (C) cai dow (M)	gin kong	sasage	dua-dua	*Vigna unguiculato* var. *sesquipedalis*
Bitter melon	ku gua (M) fu gua (C)	ssunoi	nigauri	muop dang kho qua	*Momordica charantia*
Burdock root	ngao pong (C)	uang	gobo		*Arctium lappa*
Chinese broccoli or Chinese kale	gai lan (C) jie lan (M)		kailaan	cai ro	*Brassica alboglabra*
Nappa cabbage Chinese cabbage	siew choy (C) won bok (C) da bai cai (M) huan ya bai (M)	baechu	hakusai	cai bac thao cai dai	*Brassica campestris Pekinensis* group var. *cephalata*
Chinese chives	gow choy (C) jiu cai (M)	buchu	nira	he	*Allium tuberosum*
Chinese cucumber	wong gua	oi		dua leo	*Cucumis sativus*
Big leaf mustard	dai gai choy (C) da jie cai (M)	gat	karashina	cai zanh	*Brassica juncea* var. *involutus;* var. *foliosa*
Chinese okra	si gua		hechima	muop khia muop huong	*Luffa acutangula* *Luffa cylindrica*
Chinese squash/ pumpkin	nam gua (C) nan gua (M)	ho bak	kabocha	bi ro	*Cucurbita moschata*
Chrysanthemum greens	tong hao cai (M) tong ho choy (C)	ssukgat	shungiku	tan o cai cui	*Chrysanthemum coronarium*
Flowering edible rape	yow choy (C) you cai (M)	yuchaeip	aburana	cai ngot	*Brassica campestris* var. *oleifera*
Fuzzy squash	mao gua, jie gua (M) tsit gua (C)	ho bak	tohgan	bi chanh	*Benincasa hispida* var. *chieh-qua*
Edible mallow (melokhia)				rau day	*Corchorus olitorius*
Red/green mustards	gai choy (C) jie cai (M)	gat	karashina	cai xanh	*Brassica juncea* var. *rugosa;* var. *crispifolia*
Malabar spinach	lo kwai (C) san choy (C) zi luo kui (M) lu luo (M)		tsuru-murasaki	mong to'i	*Basella alba* *Basella rubra*
Flowering Chinese leaf cabbage	choy sum (C) cai xin (M)			cai ngot non	*Brassica campestris Chinensis* group var. *utilis*
Flat flowering Chinese leaf cabbage	nai yow choy (C)				*Brassica campestris Chinensis* group var. *utilis*
Rosette Chinese leaf cabbage	tak choy (C) wu ta cai (M)		tatsoi	cai tua xai	*Brassica campestris Chinensis* group var. *rosularis*
Purple mint Beefsteak plant	zi su (C)	dulketip	shiso	tia to	*Perilla frutescens* *Perilla crispa*
Asian radish	lo bok (C) luo bu (M)	moo	daikon	cu-cai	*Raphanus sativum* *Longipinnatus* group
Potherb mustard	shui cai (C)		kyona mizuna		*Brassica juncea* var. *japonica*
Salad rocket (arugula)					*Eruca vesicaria*
Snow peas	ho lan dow	wando	saya endo		*Pisum sativum* var. *macrocarpon*
Snow pea shoots	dow miu (C) dou miao (M)	wandusun	tohbyo		*Pisum sativum* var. *macrocarpon*
Thick petiole white Chinese leaf cabbage	bai cai (M) bok choy (C)	bok choy	shakushina		*Brassica campestris Chinensis* group var. *communis*
Thin petiole white Chinese leaf cabbage	pak choy (C) xiao bai cai (M)	pak choy	shakushina chingensai (green stem)		*Brassica campestris Chinensis* group var. *communis*
Water spinach	tung choy (C) kongxin cai (M)	kongshim-chae	kankon asagaona ensai	rau muong	*Ipomoea aquatica*
Winter melon	tung kwa (C) don gua (M)		tohgan	bao	*Benincasa hispida*

TABLE 5–53. Specialty Vegetables

English	Chinese	Korean	Japanese	Vietnamese	Latin
Edible amaranth (callaloo, tampala)	hinn choy (C) xian cai (M)	chambirum	hi yu na	rau den do	*Amaranth mangostanus* *A. gangeticus*
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Bitter melon	ku gua (M) fu gua (C)	ssunoi	nigauri	muop dang kho qua	*Momordica charantia*
Burdock root	ngao pong (C)	uang	gobo		*Arctium lappa*
Chinese broccoli or Chinese kale	gai lan (C) jie lan (M)		kailaan	cai ro	*Brassica alboglabra*
Nappa cabbage Chinese cabbage	siew choy (C) won bok (C) da bai cai (M) huan ya bai (M)	baechu	hakusai	cai bac thao cai dai	*Brassica campestris Pekinensis* group var. *cephalata*
Chinese chives	gow choy (C) jiu cai (M)	buchu	nira	he	*Allium tuberosum*
Chinese cucumber	wong gua	oi		dua leo	*Cucumis sativus*
Big leaf mustard	dai gai choy (C) da jie cai (M)	gat	karashina	cai zanh	*Brassica juncea* var. *involutus;* var. *foliosa*
Chinese okra	si gua		hechima	muop khia muop huong	*Luffa acutangula* *Luffa cylindrica*
Chinese squash/ pumpkin	nam gua (C) nan gua (M)	ho bak	kabocha	bi ro	*Cucurbita moschata*
Chrysanthemum greens	tong hao cai (M) tong ho choy (C)	ssukgat	shungiku	tan o cai cui	*Chrysanthemum coronarium*
Flowering edible rape	yow choy (C) you cai (M)	yuchaeip	aburana	cai ngot	*Brassica campestris* var. *oleifera*
Fuzzy squash	mao gua, jie gua (M) tsit gua (C)	ho bak	tohgan	bi chanh	*Benincasa hispida* var. *chieh-qua*
Edible mallow (melokhia)				rau day	*Corchorus olitorius*
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Malabar spinach	lo kwai (C) san choy (C) zi luo kui (M) lu luo (M)		tsuru-murasaki	mong to'i	*Basella alba* *Basella rubra*
Flowering Chinese leaf cabbage	choy sum (C) cai xin (M)			cai ngot non	*Brassica campestris Chinensis* group var. *utilis*
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Rosette Chinese leaf cabbage	tak choy (C) wu ta cai (M)		tatsoi	cai tua xai	*Brassica campestris Chinensis* group var. *rosularis*
Purple mint Beefsteak plant	zi su (C)	dulketip	shiso	tia to	*Perilla frutescens* *Perilla crispa*
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Potherb mustard	shui cai (C)		kyona mizuna		*Brassica juncea* var. *japonica*
Salad rocket (arugula)					*Eruca vesicaria*
Snow peas	ho lan dow	wando	saya endo		*Pisum sativum* var. *macrocarpon*
Snow pea shoots	dow miu (C) dou miao (M)	wandusun	tohbyo		*Pisum sativum* var. *macrocarpon*
Thick petiole white Chinese leaf cabbage	bai cai (M) bok choy (C)	bok choy	shakushina		*Brassica campestris Chinensis* group var. *communis*
Thin petiole white Chinese leaf cabbage	pak choy (C) xiao bai cai (M)	pak choy	shakushina chingensai (green stem)		*Brassica campestris Chinensis* group var. *communis*
Water spinach	tung choy (C) kongxin cai (M)	kongshim-chae	kankon asagaona ensai	rau muong	*Ipomoea aquatica*
Winter melon	tung kwa (C) don gua (M)		tohgan	bao	*Benincasa hispida*

TABLE 5–54.
Specialty Vegetables Insect Control Recommendations

Common Name	Group	Trade name	Rate per Hectare	Days to Harvest	Notes
Aphid					
dimethoate	organophosphate	Cygon 480 E	0.6–1.0 L	7	Chinese broccoli, Chinese cabbage, pak choy. Maximum of 3 applications per season.
		Lagon 480 E	0.6–1.0 L	7	Chinese broccoli, Chinese cabbage, pak choy. Maximum of 3 applications per season.
naled	organophosphate	Dibrom EC	1.1–1.65 L	4	Mustard greens. Maximum of 3 applications per season.
Cutworm					
chlorpyrifos	organophosphate	Lorsban 4E	2.4 L preplant or 1.2–2.4 L on seedlings	32	Chinese cabbage
		Pyrinex 480 EC	2.4 L preplant or 1.2–2.4 L on seedlings	32	Chinese cabbage
Cabbage Looper, Diamondback Moth, Imported Cabbageworm					
bacillus thuringiensis	microbial	Dipel 2XDF	275–550 g	0	Mustard Greens
			55–550 g	0	Chinese cabbage, Chinese broccoli, Bok choy, Asian radish
		Thuricide HPC	2.0–4.25 L	0	Mustard Greens
carbaryl	carbamate	Sevin XLR Li	2.5–5.25 L	21	Chinese cabbage, mustard greens
naled	organophosphate	Dibrom EC	1.1–1.65 L	4	Mustard Greens (Looper only)
permethrin	pyrethroid	Pounce 384 EC	90–180 mL	3	Pak choy, Chinese cabbage
				7	Chinese broccoli
azinphos-methyl	organophosphate	Guthion 50 WP Solupak	1.12–1.75 kg	21	Chinese cabbage
Flea Beetle					
carbaryl	carbamate	Sevin XLR Li	1.25–2.5 L	21	Chinese cabbage, Mustard Greens
Tarnished Plant Bug					
carbaryl	carbamate	Sevin XLR Li	2.5–5.25 L	21	Chinese cabbage, Mustard Greens
Cabbage Maggot					
azinphos-methyl	organophosphate	Guthion 50 WP Solupak	1 kg in 1,000 L water	21	Chinese cabbage. Apply 115–170 mL per plant at or immediately after transplanting.
		Guthion 240 SC	2 L in 1,000 L water	21	
chlorpyrifos	organophosphate	Lorsban 4E	2–7 L	15	Chinese cabbage, pak choy only.
			Rate varies with row spacing (see label). Apply 7–10 days after seeding or 3 days after transplanting. Repeat 21 days after transplant drench or 28 days after seeding drench.		
		Lorsban 4E or Pyrinex 480 EC	210 mL/1,000 metres of row	32	Asian-type radish (lo bok, daikon, moo)
			Apply 7, 20 and 35 days after seeding.		
		Lorsban 4E or Pyrinex 480 EC	150 mL/1000 metres of row	21	Chinese broccoli (gai lan, kailaan).
			Apply 5–7 days after seeding as an over-the-row drench.		

SPINACH & SWISS CHARD

Cultivars

Spinach varieties listed in Table 5–55, *Spinach Cultivars*, right, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. In some cases, other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under Ontario growing conditions. Varieties of crops change frequently; check with a range of seed company representatives for additional recommendations and variety descriptions.

See your seed catalogues for suitable Swiss chard varieties.

TABLE 5–55.
Spinach Cultivars

Cultivar	Type of Leaf
Long Bloomsdale (spring, limited seed supply)	savoyed
Melody (summer, fall, overwintering)	medium
Unipak 151	medium
Unipak 12	smooth
Springfield	smooth
Space	smooth
Olympia	smooth

Bolting

Spinach quickly bolts (produces flowerstalks) under long-day and warm-weather conditions. This explains why the crop is produced mostly in the spring or fall. Cool weather reduces the long-day effect. Spinach grown in cool summers may not bolt quickly. Bolting may also be hereditary. Strains of spinach deteriorate in quality if the seed producer allows the quick-bolting types to increase.

Seed Treatment

Treat seed with a thiram (dithiocarbamate group) or captan (phthalimide group) seed protectant.

Seeding and Spacing

Sow outside as soon as soil can be worked in early spring until early May, or from July 31 to August 31 for a fall crop. Do not sow seed in mid-summer, because bolting may occur. For over-wintered spinach, sow from September 1–10. About 12 kg of seed will plant 1 hectare. Fresh seed will germinate readily at soil temperatures as low as 3°C–4°C, and good results are obtained at 10°C–16°C. At higher temperatures, there is a more rapid emergence but decreased percentage germination. The ability to germinate in cool soil permits very early sowing in spring.

Spinach seed more than a year old rarely germinates over 80%. Older seed is even less viable and germinates more slowly and irregularly. Space rows 30 cm apart, with plants 5–10 cm apart in the row.

Swiss chard is seeded in the spring in rows approximately 30 cm apart with plants 10–12 cm apart in the row.

Soil

Sandy or sandy-loam soils are preferred for the early and over-wintered crops. The highest yields are obtained on muck soils. Muck soils have a high water-holding capacity and are well-aerated. Since spinach is somewhat sensitive to soil acidity, a test should be made before planting the crop. The ideal range for spinach is a pH of 6.5–7.5.

Fertilizer

Boron

Boron deficiencies on spinach and swiss chard are not common but may occur during periods of hot, dry weather. Leaves may become twisted with light spots developing on the petioles. Internal breakdown may occur in the roots or may appear on the root surface as external cankers. General symptoms include breakdown of young tissues and slow growth. Consult the section *Boron* on page 27 and Table 3–8 on page 26.

Magnesium

A magnesium deficiency may occur on spinach. The usual symptoms are yellowing of older leaves while the veins remain dark green. Consult the section *Magnesium* on page 26 and Table 3–8 on page 26.

Nitrogen

On mineral soils, apply up to 110 kg N/ha. On muck soils, apply 75 kg N/ha. If manure is applied or legume sod is plowed down, reduce the nitrogen application. (See Table 3–10 and Table 3–11 on page 28 and page 29).

Application

All of the nitrogen may be applied at the time of planting for early-sown crops on mineral soil. Apply only half of the recommended amount of nitrogen for mid-season or later crops.

Side-dress the mid-season or late crop with 55 kg N/ha following excessive rainfall, especially on sandy soils.

On muck soils, although the recommended amount of nitrogen should normally be considered maximum, it may be permissible following excessive rainfall to side-dress with an additional 55 kg N/ha.

TABLE 5–56.
Spinach & Swiss Chard Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Leaf Miner					
parathion	organophosphate	Parathion 960 EC	225–375 mL	7	Spinach only. Minimum period for re-entry is 7 days.
malathion	organophosphate	Malathion 25 W	5.5–7.0 kg	7	Spinach only.
diazinon	organophosphate	Diazinon 50 WP	1.1 kg	10	Spinach only.
		Diazinon 500 EC	1.1 L	10	
		DZN 600 EW	0.915 L	10	
				14	Swiss chard.
Aphid					
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.75 kg	14	Spinach only. Make only one application.
		Thiodan 4 EC	2.0 L	14	
		Endosulfan 50 W	1.75 kg	14	
		Thionex 400 EC	2.0 L	14	
diazinon	organophosphate	Diazinon 50 WP	1.1 kg	10	Spinach only. Control of aphids with diazinon has been inconsistent in many areas.
		Diazinon 500 EC	1.1 L	10	
		DZN 600 EW	0.915 L	10	
				14	Swiss chard. Control of aphids with diazinon has been inconsistent in many areas.
parathion	organophosphate	Parathion 960 EC	225–375 mL	7	Spinach only. Minimum period for re-entry is 7 days.
dimethoate	organophosphate	Cygon 480 E	0.7 L	7	
		Lagon 480 E	0.7 L	7	
naled	organophosphate	Dibrom EC	1.1–1.65 L	4	Control of aphids with naled has been inconsistent in many areas.
Cabbage Looper & Beet Webworm					
Bacillus thuringiensis	microbial	Thuricide HPC	2.0–4.25 L	0	Spinach only. Looper only.
		Dipel 2XDF	275–550 g	0	
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.75 kg	14	Spinach only. Looper only. Make only one application.
		Thiodan 4 EC	2.0 L	14	
		Endosulfan 50 W	1.75 kg	14	
		Thionex 400 EC	2.0 L	14	
parathion	organophosphate	Parathion 960 EC	225–375 mL	7	Spinach only. Webworm & looper. Minimum period for re-entry is 7 days.
naled	organophosphate	Dibrom EC	1.1–1.65 L	4	

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 3–5, Table 3–6 and Table 3–7 on page 24 and page 25).

Disease Management

Damping-Off

See the sections *Seed Treatment* on page 11 and *Damping-Off of Seedlings* on page 12.

Downy Mildew and Mosaic Virus

Grow a resistant cultivar. Do not grow a fall crop in, or adjacent to, a field where an infected spring crop was grown. For mosaic virus, control of aphids is also helpful.

Fusarium Wilt and Root Rot

In soils where this disease is a problem, do not seed spinach between May 31 and August 15. Some tolerance may exist in some varieties. Check with your seed company representatives for further information.

Insect Management

Leaf Miner, Aphids, Cabbage Looper & Beet Webworm

If monitoring indicates a need, use one of the pesticides recommended in Table 5–56, *Spinach & Swiss Chard Insect Control Recommendations*, above. Use pesticides for aphids in rotation.

Nematode Control

To avoid damage from sugar beet cyst nematode, do not plant spinach following rhubarb, beets or spinach. (See the section *Nematodes* on page 17.)

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SWEET CORN

Cultivars

The corn varieties listed are suggestions for Ontario from seed companies, growers, researchers and extension personnel. In some cases, other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under Ontario growing conditions. Varieties of crops change frequently; check with a range of seed company representatives for additional recommendations and variety descriptions.

The sweet corn cultivars listed in Table 5–57, *Sweet Corn Cultivars,* below, were submitted by seed companies for a coordinated trial in 1999. They are not necessarily the most widely grown but may represent some of the new varieties that seed companies are promoting.

The cultivars listed in Table 5–57, *Sweet Corn Cultivars,* below, were planted at research stations in Ridgetown and Simcoe, Ontario. Data presented are averages of the two sites. Where data were not available from both sites, data from one site are presented. The cultivar trials measured more traits than are listed here. Full reports on the trials can be obtained by contacting the institution where the trial took place.

These cultivars are intended for fresh market corn. For processing corn, the choice of cultivar should be discussed with a representative of the processing company.

For more information, consult the OMAFRA Factsheet, *High Sugar Sweet Corn,* Order No. 90-126 and OMAFRA Publication 12, *Sweet Corn Production Manual.*

TABLE 5–57.
Sweet Corn Cultivars

DTH[1]	CHU[2]	Cultivar	Type[3]	Colour[4]	Percent Plant Stand	Ease of Snap[5]	Cob Length cm	Roadside Rating[6]	Yield doz/ha
68	1802	HMX 5346 E	Se[7]	Y	86	4	18.3	3.2	3532
69	1812	Sweet Riser	SB[8]	Y	84	3.6	17.6	3.8	3282
69	1823	Ecstace II	Se[7]	Bi	67	4	17.6	3.3	2427
71	1863	Everprime	Sh2[9]	Bi	74	3.7	18.8	3.7	2860
71	1871	Double Choice	Su[10]	Bi	89	3	20.3	3.8	3333
72	1887	HMX 6361 BS	Sh2[9]	Bi	79	3.9	19.2	3.4	3638
72	1883	Temptation	Se[7]	Bi	94	3.1	16	3.6	3644
73	1901	HMX 5352 BS	Sh2[9]	Bi	78	4.4	20	3.4	3800
74	1936	HMX 6357 BSB	SB[8]	Bi	73	3.2	20.2	3.5	3108
76	1997	HMX 8342 BES	Se[7]	Bi	84	3.8	19.2	3.7	3175
77	2020	Fantasy	Sh2[9]	Bi	68	3.7	18.1	2.9	1904
78	2039	Double Dots	Sh2[9]	Bi	72	4.1	18.3	3.6	2404
78	2045	Amazingly Sweet	Sh2[9]	Bi	82	4.3	18.9	3.5	3485
79	2060	EX 8414607	Sh2[9]		90	4.1	19.2	3.4	2877
80	2092	HMX 7366 BES	Se[7]	Bi	86	3.4	20.6	3.6	3845
83	2149	Twilight	Se[7]	Bi	70	4.1	18.2	3.7	4018
83	2153	Table Treat	Se[7]	Bi	88	4.6	21.5	3.1	3281
84	2176	HMX 5348 BES	Se[7]	Bi	77	3.7	20.9	4.1	3847
87	2251	HMX 6364 BS	Sh2[9]	Bi	78	4.8	18.6	3.8	2599

[1] Actual days to harvest at trial site.
[2] Corn heat units from planting to harvest
[3] Gene type of the cultivar. There are several types of sweet corn.
[4] Y = yellow, Bi = bicolour, W = white
[5] Ease of Snap: 1 = difficult; 5 = easy
[6] Roadside Rating summarizes ratings for tip cover, shank length, husk colour, husk tightness, flag leaf appearance, ear fill, row uniformity, colour contrast and row straightness. 1 = poor; 5 = good
[7] Sugar Enhanced Sweet Corn: They have higher sugar levels and also convert their sugar to starch quickly.
[8] Sweet Breed: Contain a mixture of Su, Se and Sh2 genes. These cultivars combine high sugar content with cold soil tolerance.
[9] Supersweet Sweet Corn: They often have the highest sugar levels of all 3 types. They do not convert sugar to starch readily and therefore stay sweet the longest. Seeds do not grow well in cold soils.
[10] Normal Sweet Corn – the traditional cultivars that have been available for years. They have normal sugar levels and convert their sugar to starch quite quickly.

SWEET CORN

Cultivars

The corn varieties listed are suggestions for Ontario from seed companies, growers, researchers and extension personnel. In some cases, other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under Ontario growing conditions. Varieties of crops change frequently; check with a range of seed company representatives for additional recommendations and variety descriptions.

The sweet corn cultivars listed in Table 5–57, *Sweet Corn Cultivars,* below, were submitted by seed companies for a coordinated trial in 1999. They are not necessarily the most widely grown but may represent some of the new varieties that seed companies are promoting.

The cultivars listed in Table 5–57, *Sweet Corn Cultivars,* below, were planted at research stations in Ridgetown and Simcoe, Ontario. Data presented are averages of the two sites. Where data were not available from both sites, data from one site are presented. The cultivar trials measured more traits than are listed here. Full reports on the trials can be obtained by contacting the institution where the trial took place.

These cultivars are intended for fresh market corn. For processing corn, the choice of cultivar should be discussed with a representative of the processing company.

For more information, consult the OMAFRA Factsheet, *High Sugar Sweet Corn,* Order No. 90-126 and OMAFRA Publication 12, *Sweet Corn Production Manual.*

TABLE 5–57.
Sweet Corn Cultivars

DTH[1]	CHU[2]	Cultivar	Type[3]	Colour[4]	Percent Plant Stand	Ease of Snap[5]	Cob Length cm	Roadside Rating[6]	Yield doz/ha
68	1802	HMX 5346 E	Se[7]	Y	86	4	18.3	3.2	3532
69	1812	Sweet Riser	SB[8]	Y	84	3.6	17.6	3.8	3282
69	1823	Ecstace II	Se[7]	Bi	67	4	17.6	3.3	2427
71	1863	Everprime	Sh2[9]	Bi	74	3.7	18.8	3.7	2860
71	1871	Double Choice	Su[10]	Bi	89	3	20.3	3.8	3333
72	1887	HMX 6361 BS	Sh2[9]	Bi	79	3.9	19.2	3.4	3638
72	1883	Temptation	Se[7]	Bi	94	3.1	16	3.6	3644
73	1901	HMX 5352 BS	Sh2[9]	Bi	78	4.4	20	3.4	3800
74	1936	HMX 6357 BSB	SB[8]	Bi	73	3.2	20.2	3.5	3108
76	1997	HMX 8342 BES	Se[7]	Bi	84	3.8	19.2	3.7	3175
77	2020	Fantasy	Sh2[9]	Bi	68	3.7	18.1	2.9	1904
78	2039	Double Dots	Sh2[9]	Bi	72	4.1	18.3	3.6	2404
78	2045	Amazingly Sweet	Sh2[9]	Bi	82	4.3	18.9	3.5	3485
79	2060	EX 8414607	Sh2[9]		90	4.1	19.2	3.4	2877
80	2092	HMX 7366 BES	Se[7]	Bi	86	3.4	20.6	3.6	3845
83	2149	Twilight	Se[7]	Bi	70	4.1	18.2	3.7	4018
83	2153	Table Treat	Se[7]	Bi	88	4.6	21.5	3.1	3281
84	2176	HMX 5348 BES	Se[7]	Bi	77	3.7	20.9	4.1	3847
87	2251	HMX 6364 BS	Sh2[9]	Bi	78	4.8	18.6	3.8	2599

[1] Actual days to harvest at trial site.
[2] Corn heat units from planting to harvest
[3] Gene type of the cultivar. There are several types of sweet corn.
[4] Y = yellow, Bi = bicolour, W = white
[5] Ease of Snap: 1 = difficult; 5 = easy
[6] Roadside Rating summarizes ratings for tip cover, shank length, husk colour, husk tightness, flag leaf appearance, ear fill, row uniformity, colour contrast and row straightness. 1 = poor; 5 = good
[7] Sugar Enhanced Sweet Corn: They have higher sugar levels and also convert their sugar to starch quickly.
[8] Sweet Breed: Contain a mixture of Su, Se and Sh2 genes. These cultivars combine high sugar content with cold soil tolerance.
[9] Supersweet Sweet Corn: They often have the highest sugar levels of all 3 types. They do not convert sugar to starch readily and therefore stay sweet the longest. Seeds do not grow well in cold soils.
[10] Normal Sweet Corn – the traditional cultivars that have been available for years. They have normal sugar levels and convert their sugar to starch quite quickly.

Seeding and Spacing

Depending on seed size, 11–17 kg of seed are required to plant 1 ha. Where small seed is used, the lower amount is sufficient.

Plant early cultivars in rows as close as 75 cm apart, with plants 18–20 cm apart.

The smaller, earlier maturing varieties can be planted at higher densities while the larger, later varieties require more room to grow and develop. If only one row width is practical, it is more critical to use wider spacing to accommodate the larger, main-season plants.

Soil Temperature

Minimum soil temperature for germination depends on the cultivar and its gene type. In general, "su" cultivars require 13°C, "se" cultivars require 16°C, and "sh2" cultivars require 18°C.

Fertilizer

Nitrogen

On all soils, 90 kg N/ha is recommended. If manure is applied or legume sod is plowed down, reduce the nitrogen application. (See Table 3–10 and Table 3–11 on page 28 and page 29.)

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 3–5, Table 3–6 and Table 3–7 on page 24 and page 25.)

Application

A portion of the nitrogen and phosphorus required should be applied at seeding in 1 of 2 ways:

1. In a band 5 cm to the side and 5 cm below the seed. The rate of application in the band should not be more than 75 kg N/ha or a total of 120 kg of nitrogen plus potash (K_2O) per hectare in 75 cm rows. If urea is the nitrogen source, not more than 40 kg nitrogen or 80 kg of nitrogen-plus-potash/ha should be applied, in 75-cm rows.

2. In a band directly with the seed. With this placement, not more than 9 kg nitrogen-plus-potash/ha should be applied, in 75 cm rows. A major portion of the nitrogen should be applied pre-plant or side-dressed before the corn is 30 cm high. A major portion of the potash may be broadcast and worked in either in the fall or before seeding in the spring.

As phosphate does not move readily in the soil, and since it is required early in the plant's growth, it is best banded at time of planting. As a result, there may be little need for the broadcast application of phosphate, depending upon the soil test rating.

Micronutrients

Zinc

Visual symptoms on the leaves are the best means of determining deficiency, but soil tests are also useful. Where zinc is required, it may be applied to the soil mixed in the fertilizer at rates supplying 4–12 kg zinc/ha. The higher rate should be sufficient for up to 3 years. Not more than 4 kg zinc/ha should be banded at seeding. Zinc may be applied as a spray at rates of 0.3–0.7 kg zinc/ha in 300 L of water. A wetting agent should be added. For more information, consult the OMAFRA Factsheet *Zinc Requirements for Field Crops*, Order No. 83-089, and consult the section *Zinc* on page 27 and Table 3–10 on page 28.

Bird and Animal Management

Red-Winged Black Birds and Crows

Acetylene exploders are effective, but birds will soon resume feeding when exploders are not operating. For full effectiveness, locate exploders above the cornstalks and move them around frequently. Constant patrolling and shooting during morning and evening feeding periods is effective but expensive. Plant away from marshy and wooded areas. Cultivars with ears well-covered by husks are somewhat resistant to blackbirds.

Av-Alarm electronic bird-scaring devices have sometimes been used successfully to repel large flocks of birds from fields of sweet corn.

Raccoons and Skunks

Shoot or trap in season. Plant the crop away from wooded areas. An electric fence with three strands placed at 8–10 cm intervals from the ground has given satisfactory control.

Disease Management

Three-Leaf Dieback

Seedlings may die before or shortly after emergence, resulting in poor stand. Sh2 cultivars planted into cool soils are most susceptible. Two fungi are responsible: *Penicillium* occurs as a contaminant on the seed, whereas *Pythium* is common in most soils. To prevent three-leaf dieback, apply DCT as a seedbox treatment at planting time.

Leaf Blights, Stalk Rots, Ear Rots

Rotate corn with unrelated crops such as peas, carrots, potatoes, beans and tomatoes. Plow under old cornstalks and leaves. Maintain well-balanced soil fertility.

Common Smut

Remove and destroy galls on infected plants before spores are released. Excessive nitrogen can render plants more susceptible to infections. Minimize mechanical injury to plants during field operations. Although crop rotation may help, smut spores may blow in from other contaminated fields.

Stewart's Wilt

There is no control for this disease, but it can be prevented by choosing varieties resistant to Stewart's wilt. Ask your seed company representative about disease susceptibility ratings. Susceptible varieties can be protected by controlling corn flea beetles, which vector the disease. Plants younger than 5 leaves develop yellow-striped leaves, then may wilt and die. Older plants develop yellow-striped leaves but continue to grow and produce ears.

Rust

This fungal disease becomes noticeable towards the end of summer. Cool weather (16°C–23°C) with overnight dew favours disease progress. Epidemics arise from spores blown in by winds from infected corn crops south of the border. There is a range of rust resistance in sweet corn cultivars. Early planting ensures that the crop develops before infection from summer spores become common. If rust has been a serious problem, apply one of the fungicides recommended in Table 5–58, *Sweet Corn Insect and Disease Control Recommendations*, on page 132.

Insect Management

Seed Maggots and Wireworms

Treat seed with diazinon (organophosphate group) and lindane (polychlorocycloalkane group). See the section *Chemical Seed Treatment* on page 11.

Corn Flea Beetles

These small (2 mm) black beetles cause elongated scratches on the leaves. This is rarely significant by itself, but the beetles can carry Stewart's wilt disease, which can cause significant losses. The risk is greatest in May and June, before the plants reach the 5-leaf stage. Mild winters increase beetle survival and increase the risk of Stewart's wilt transmission.

Cutworms

Cutworms are an occasional pest of sweet corn. If monitoring indicates a problem, consult the section *Cutworms* on page 16 for cutworm management recommendations.

Corn Earworm and Fall Armyworm

These two late-season pests are not known to overwinter in Ontario. Instead, they are carried by winds across the Great Lakes from the United States. The fall armyworm generally first appears in late July to early August, while the corn earworm blows in from early August to mid-September. The larvae of both species attack the ear causing economic injury to late-planted fresh market and processing sweet corn. Both pests can be monitored by pheromone traps. Also monitor fields carefully for young larvae in ears. Effective control has been obtained by using one of the synthetic pyrethroids directed at the ear zone. The recommendations in Table 5–58, *Sweet Corn Insect and Disease Control Recommendations*, on page 132, when applied for corn earworm control will also control the fall armyworm.

Aphids

Repeated use of pyrethroid insecticides may increase the population of aphids by killing the beneficial insects that normally feed on them. To minimize aphid problems, do not use pyrethroid insecticides unless corn earworms or fall armyworms are present, or the crop is within 1 week of harvest. If monitoring indicates a need, apply one of the insecticides recommended in Table 5–58 on page 132.

Corn Rootworm

Where corn rootworm has been a problem, crop rotation is recommended. For adult control, products used for European Corn Borer control will reduce populations of rootworm adults.

European Corn Borer

This insect is a major pest of sweet corn in Ontario. There are two generations of corn borer per year (bivoltine strain) in southwestern Ontario, south of an imaginary line extending from Sarnia through London and Simcoe to Niagara Falls. Generally there is only one generation per year (univoltine strain) throughout the rest of the province. A broad overlap area on either side of this line may have a mix of the two corn borer strains. Bivoltine adults are most abundant in June and August, and the greatest damage occurs in July and September. Univoltine adults are abundant in July, with the greatest damage in August.

Sweet corn is susceptible to corn borer from the late-whorl stage (12–14 leaves emerged and when the tassel can be felt inside the whorl) until the silks dry. If corn borer adults are present during this time, then the field should be inspected weekly for egg masses and/or pinhole feeding.

TABLE 5–58.
Sweet Corn Insect and Disease Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Rust					
propiconazole	triazole	Topas 250 E	500 mL	14	Do not apply after silking.
chlorothalanil	chloronitrile	Bravo 500 F	3.2 L	14	Do not apply more than 2 times per season.
European Corn Borer					
permethrin	pyrethroid	Pounce 384 EC	275–375 mL	1	
cypermethrin	pyrethroid	Cymbush 250 EC	280 mL	5	
		Ripcord 400 EC	175 mL	5	Maximum of 3 ground applications or 2 aerial applications/year.
carbaryl	carbamate	Sevin XLR Li	2.5–4.0 L	1	
carbofuran[1]	carbamate	Furadan 480 F	1.1 L	7	Do not apply more than 2 times per season. Minimum period for reentry is 48 hours.
methomyl	carbamate	Lannate SP	625 g	3	Minimum period for re-entry is 24 hours.
acephate	organophosphate	Orthene SP	0.75–1.1 kg	21	Do not apply more than 4 times per season.
deltamethrin	pyrethroid	Decis 5.0 EC	250–300 mL	5	Do not apply more than 2 times per season.
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	1	Do not apply more than 3 times per season. Minimum period for re-entry is 24 hours.
Corn Earworm and Fall Armyworm					
cypermethrin	pyrethroid	Ripcord 400 EC	175 mL	5	Maximum 3 ground applications or 2 aerial applications/year.
permethrin	pyrethroid	Pounce 384 EC	275–375 mL	1	
methomyl	carbamate	Lannate SP	430–625 g	3	For earworm only. Minimum period for re-entry is 24 hours.
deltamethrin	pyrethroid	Decis 5.0 EC	250–300 mL	5	For earworm only. Do not apply more than 2 times per season.
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	1	Do not apply more than 3 times per season. Minimum period for re-entry is 24 hours.
Aphid					
pirimicarb	carbamate	Pirimor 50 DF	550 g	3	Ground application. 34–50 L of water/ha.
				3	Aerial applications. 20–45 L of water/ha. Make only 1 application/season.
Corn Rootworm					
carbofuran	carbamate	Furadan 480 F	0.5 L/ha	7	Minimum period for reentry is 48 hours.

[1] If prolonged direct contact with corn foliage will occur, do not re-enter treated fields between 2–14 days of application without wearing appropriate protective clothing such as long pants and long-sleeved shirt. See the section *Protective Outdoor Clothing* on page 4.

Eggs are white and are laid in masses containing 5–50 eggs that resemble overlapping fish scales. They are most often laid on the underside of the upper leaves, near the midrib. Early larvae feed on the leaves, making several small feeding holes in one area (pinholes). However, since monitoring for egg masses is difficult and time consuming, the initiation of a spray program is usually based on the presence of this pinhole feeding, detected through field inspections.

Apply an insecticide when pinhole feeding is observed on at least 5% of the plants. If the tassel has not yet completely emerged, spray down into the whorl. After that time, direct the spray toward the ear zone.

Application at 5–7 day intervals usually gives satisfactory control. This interval may vary with temperature and material used (consult manufacturer's label directions). None of the insecticides listed will kill corn borer eggs. If eggs are present when sprays are applied, the residual activity of the product will normally kill corn borer larvae as they hatch. Check monitoring information for reports on corn borer activity in your area, if available. Note that temperatures and relative humidity greatly affect the effectiveness of insecticides. Consult the section *Spraying Vegetable Crops* on page 14 for comments about weather effects on sprays.

M121

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There are now transgenic varieties of sweet corn with the Bt gene, which gives them complete resistance to corn borers and partial resistance to earworms and fall armyworms, reducing the need for insecticides. Some insecticides may be needed for other pests if pressure is high. Check with your seed company representative for availability and planting restrictions.

To reduce the threat of major corn borer infestations, rotate your sweet corn planting with other vegetable crops and keep grassy weeds bordering fields and in ditch banks under control.

If monitoring indicates a need, spray with one of the pesticides recommended in Table 5–58, *Sweet Corn Insect and Disease Control Recommendations*, on page 132.

For more information, consult the OMAFRA Factsheets *Insects and Diseases of Sweet Corn in Ontario*, Order No. 94-027, *European Corn Borer in Sweet Corn and Other Horticultural Crops*, Order No. 97-019, and *Corn Earworm*, Order No. 95-065.

Bee Warning

Bees often visit sweet and field corn to collect pollen. Where spraying is being done, bee poisoning may result. Carbaryl, carbofuran and permethrin are highly toxic to bees. Damage to bees is reduced when sprays are applied in early morning or late evening when bees are not foraging. Do not treat when the wind is blowing. Avoid spray drift to roadsides and adjacent fields where plants might be in bloom.

Advise local beekeepers of spraying activity (see the section on *Bee Poisoning* on page 8).

Visit the vegetable page on the OMAFRA Web site at http://www.gov.on.ca/OMAFRA/english/crops/hort/vegetable.html

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TOMATO

Cultivars

Varieties listed in Table 5–59, *Tomato Cultivars*, right, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. In some cases, other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under Ontario growing conditions. Varieties of crops change frequently; check with a range of seed company representatives for additional recommendations and variety descriptions.

Cultivars for Commercial Processing

Follow processors' requirements.

Seed Treatment

Sow seed treated with acid, chlorine or hot water for bacterial disinfection (see the section *Hot-Water Treatment* on page 11). Treat dry seed with thiram (dithiocarbamate group) seed protectant.

Transplants

Fresh market tomatoes should be established from greenhouse-grown, container-type transplants. Older transplants grown in larger containers such as 24- or 38-cell trays will promote earlier maturity. Transplants for mid-season or late maturing crops can be grown in smaller containers including 72-, 128- or 200-cell trays. Smaller cells such as the 288-plug tray may be used but require more management.

Processing tomato crops may be established from southern bare-root or locally grown greenhouse plug transplants. Experience has shown that greenhouse-grown transplants are more reliable and have less potential for severe disease problems. The 288-cell tray is usually used for processing tomatoes, although 406-plug trays have been used successfully. Proper management of plug transplants is essential. Plug trays should be transported in a properly designed trailer and must be watered regularly to prevent the plug from drying out. Plugs should be moistened by dipping in water prior to transplanting to ensure that the plug does not dry out in the ground.

Storage of Plug Transplants

If field planting is delayed by rain, plug transplants can be held for up to 2 weeks with very little reduction in plant stand or vigour. Store plug transplants by placing the racks of plants outside in an area that receives direct sunlight and that is sheltered from the wind. The racks should be elevated to prevent root growth through the bottom of the plugs. Do not store plants in an enclosed trailer or barn for more than 1 or 2 days, as this will result in very soft, elongated plants. Stored transplants should be watered regu-

TABLE 5–59.
Tomato Cultivars

Cultivar	Description
Fresh Market	
Sunstart	Very early maturity (5–6 days earlier than Sunrise); small, open plant; good quality fruit for an early variety; fruit size and yield comparable to Sunrise, concentrated maturity.
Sunshine	Very early maturity, medium-sized plant, medium-large, smooth fruit, high yield potential under good growing conditions.
Red Ryder	Early, slightly ahead of Sunrise; open, compact plant, fruit size similar to Sunrise, some rough fruit on first set in cool seasons.
Sunchief	Second early maturity, vigorous plant with good cover, very large, smooth, firm fruit.
Sunbeam	Mid-season maturity, about 7 days later than Sunrise; medium large vine type; fruit is large, globeshaped, and has excellent smoothness and crack resistance; suitable for stake or ground culture.
Sunbrite	Late-season maturity, 10–14 days later than Sunrise; very large, flattened-globe-shaped fruit is very smooth and has excellent crack resistance; suitable for stake or ground culture.
Mountain Spring	Mid-late season maturity, good yield of high quality fruit; good fruit coverage, not as vigorous as Mountain Pride.
Florida 47	Late maturity, large plant, suitable for stakes or ground culture, very large, firm, high quality fruit.
Roma Tomatoes for shipping or pick-your-own	
Hybrid 882	Mid-season, paste tomato with medium sized (64 g) elongated-plum fruit; widely adapted, suitable for shipping or PYO; also called Spectrum 882.
APT 533	Pear-shaped fruit, mid-season maturity, vigorous plant with high yield potential, fruit medium-large and firm.
Daiquiri	Large, oval-shaped fruit, concentrated fruit set, open plant habit.
Aztec	Mid-season, square-round paste tomato; medium-sized fruit (85 g) fruit; jointless stem; good colour; suitable for shipping or PYO.
Puebla	Late-mid-season; medium-sized (80 g) elongated plum-shaped fruit; very smooth, with excellent colour; high yield potential; suitable for shipping or PYO.
Cherry Types	
Swifty Belle	
Camelia	
Sweet Orange	
Juliet	
Sweet Gold	

TABLE 5–60.
Nitrogen Recommendations for Processing Tomatoes

Processing Tomatoes		
Soil Type	**Hybrid**	**Open-Pollinated**
Coarse sand and sandy loams less than 2% organic matter	160–180 kg/ha	100–120 kg/ha
Loams, silt loams and sandy loams more than 2% organic matter	90–120 kg/ha	70–90 kg/ha

larly and may require fertilization and a fungicide application if stored for longer than 5–7 days.

Plant Spacing

Fresh Market

Rows 1.2–1.5 m apart, plants 30–45 cm apart.

Processing

Handpick – Same as for fresh market, see above.
Machine Harvest – Large plant type varieties may be planted on single rows at a spacing of 1.5–1.65 m between rows (depending upon bed width) and 25–30 cm between plants. Most machine harvest-type varieties will benefit from a twin-row planting arrangement. Twin rows should be spaced 45 cm apart, with 45 cm between plants within rows, on beds of 1.5–1.65-m centres. Wider beds (1.8-m centres) may make spraying and harvesting operations easier but may reduce overall yield.

Fertilizer

Nitrogen

Fresh Market Tomatoes

Apply 35–50 kg/ha of actual nitrogen pre-plant, followed by a side-dress application of 35–50 kg/ha of actual nitrogen after the first fruit are set. Avoid late side-dress applications as this may prune roots and causes blossom-end-rot. If additional nitrogen is required late in the season, it may be injected through the irrigation system.

Processing Tomatoes

The nitrogen rate will vary greatly, according to the variety, soil type, crop rotation, organic matter and soil management. Nitrogen should be applied as a pre-plant broadcast application. Apply nitrogen according to the recommendations in Table 5–60, *Nitrogen Recommendations for Processing Tomatoes*, above.

A cover crop should be seeded after harvest is completed; this will protect soil and reduce erosion. In addition, the soil will absorb and tie up nitrogen fertilizer and reduce leaching.

TABLE 5–61.
Starter Solution Recommendations for Tomatoes

For sandy soils with less than 2% organic matter, use half the recommended rates.

Soil Temperature	Starter Concentration
Less than 18°C	Use full label rate as recommended.
Between 18°C–27°C	Use half of recommended rate.
Greater than 27°C	Starter not normally required.

Starter Solution (All Tomatoes)

Apply a high phosphorus starter fertilizer in the transplant water when transplanting tomatoes. Starter fertilizer is especially important when planting in cool soils in early spring. Starter fertilizers are available in several forms including 10-34-0 or 6-24-6 liquids or granular materials such as 10-30-20 or 10-52-10. Apply according to the recommendations in Table 5–61, *Starter Solution Recommendations for Tomatoes*, above.

Phosphate and Potash

Soil tests should be used to determine phosphate and potash requirements. Phosphate and potash fertilizer should be applied as a broadcast application, prior to planting. On most soil types, a fall application of potassium and phosphorus is acceptable. (See Table 3–5, Table 3–6 and Table 3–7 on page 24 and page 25.)

Magnesium

A magesium deficiency may occur on tomatoes. The usual symptoms are yellowing of older leaves while the veins remain dark green. Consult the section *Magnesium* on page 26 and Table 3–8 on page 26.

Plasticulture For Fresh Market Tomatoes

Use of plasticulture will result in improved earliness, yield and quality of fresh market tomatoes. Plastic mulches warm the soil, conserve moisture and keep the fruit clean, thus reducing soil-borne fruit rots. Black plastic mulch is recommended because it also provides weed control. If plastic mulch is used, drip irrigation is recommended.

See the section *Plasticulture* on page 42.

Bird Management

Ring-Billed Gull Control

Ring-billed gull populations are increasing and are moving further inland along the shores of Lake Erie and Ontario. Tomato fruits are damaged by repeated feeding scars resulting in reduced yields and quality, and increased sorting costs. Overall population control is not

feasible; however, growers wishing to protect areas within a field can obtain a licence to shoot gulls. Early gull detection and control are important. For a permit, call the Enforcement Coordinator, Canadian Wildlife Service, Environment Canada, (519) 826-2100.

Disease Management

Greenhouse Seedling Production

1. Sow acid-treated, chlorine or hot-water-treated seed. (See the section *Hot-Water Treatment* on page 11.)
2. Treat seed with thiram (dithiocarbamate group). See the section *Seed Treatment* on page 11.
3. Sow in a clean, soilless mixture.
4. Disinfect all greenhouse walls, benches and equipment between crops.
5. Avoid unnecessary movement and handling of plants. Maintain good sanitation and weed control.
6. If damping-off occurs, drench soil with Ferbam (dithiocarbamate group) (see the section *Damping-Off of Seedlings* on page 12).
7. When watering, minimize the time that leaves are wet.
8. If possible, do not plant peppers and tomatoes in the same greenhouse structure.
9. If bacterial disease is a concern, apply protective copper (inorganic group) sprays every 5–7 days. Excessive use of copper can lead to disease resistance and stunting of transplants.

For more information, consult the OMAFRA Factsheets *Plug Transplants for Processing Tomatoes: Production, Handling & Stand Establishment*, Order No. 94-061, and *Fresh Market Tomato Production*, Order No. 94-019.

Bacterial Leaf Spot

It is not possible to completely control this disease with chemical sprays. The most effective results, however, have been achieved when applications are made early, before significant disease is observed. If weather conditions are favourable for bacterial disease infections prior to the initiation of the fungicide spray program using TOM-CAST, then choose one of the spray combinations recommended in Table 5–62, *Tomato Disease Control Recommendations*, on page 137. If moist, windy conditions prevail, increasing the risk of continued bacterial infections, repeat within 5 days of the initial bacterial control spray. If bacterial disease pressures continue after initiating the fungicide program, use one of these combination treatments following TOM-CAST.

Note: Avoid working in fields when foliage is wet. Wash machinery with a high pressure hose after working in contaminated fields.

Bacterial Canker, Bacterial Speck

It is not usually possible to control these diseases in the field with chemical sprays. Seed-borne bacterial canker can be prevented with a hydrochloric acid seed treatment (see page 33). There are no practical control measures for tomato bacterial diseases after they are found in the field. Clipping and handling transplants can spread disease. Avoid working in tomato fields when the foliage is wet.

Anthracnose, Early Blight, Late Blight

Spray when first fruits are about walnut size (or when first fruits appear on early cultivars). Repeat sprays as necessary. During continuous moist weather, intervals should be 5–7 days. In warm dry weather, intervals can be extended to 12–14 days if diseases are under control. For anthracnose, continue spraying until mid-September.

TOM-CAST

This is a program to help growers determine when to apply foliar fungicides in field tomatoes. It is designed for the control of early blight, *Septoria* leaf spot and fruit anthracnose. A network of mini weather stations throughout the tomato-growing regions of southwestern Ontario is used to monitor conditions favourable to disease development from which disease severity values are calculated for each day throughout the summer. Growers are advised to spray at critical values determined by TOMCAST.

Note: TOM-CAST is not available in all fresh market tomato growing regions of Ontario. Use one of the fungicides recommended in Table 5–62, *Tomato Disease Control Recommendations*, on page 137.

Septoria Leaf Spot

If monitoring indicates a need, spray with one of the fungicides recommended in Table 5–62 on page 137.

Fusarium Wilt, Verticillium Wilt

Crop rotation is recommended. Grow *Fusarium*- and *Verticillium*-wilt-resistant cultivars if suited to area and market. Soil fumigation may be recommended if root

TABLE 5–62.
Tomato Disease Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Bacterial Leaf Spot					
chlorothalanil *plus* copper	chloronitrile & inorganic	Bravo 500 F *plus* Kocide 101 WP	2.8 L 2.25 kg	1	
mancozeb *plus* copper	dithiocarbamate & inorganic	Dithane DG *plus* Kocide 101 WP	2.25 kg 2.25 kg	7	
		Manzate DF *plus* Kocide 101 WP	2.25 kg 2.2 kg	7	
copper hydroxide	inorganic	Champion 50 WP	2.25 kg	1	Should be combined with 1.75–2.25 kg/ha mancozeb. (7 days)
Anthracnose, Early Blight, Late Blight					
captan	phthalimide	Maestro 75 DF	3.0–4.5 kg	2	Anthracnose only.
		Captan 80 W	2.75–4.25 kg	2	Anthracnose only.
		Supra Captan 80 WDG	2.75–4.25 kg	2	
chlorothalanil	chloronitrile	Bravo 500 F	2.8–3.2 L	1	Under heavy disease pressure, use higher rate.
mancozeb	dithiocarbamate	Dithane DG	1.1–3.25 kg	7	
		Dithane M-45	1.1–3.25 kg	7	
		Manzate DF	1.75– 3.25 kg	7	
		Penncozeb 75 DF	1.1–3.25 kg	7	
metiram	dithiocarbamate	Polyram 80 DF	2.25–3.25 kg	7	Low rate for early and late blight; high rate for anthracnose.
Septoria Leaf Spot					
chlorothalanil	chloronitrile	Bravo 500 F	3.8 L	1	
benomyl	benzimadazole	Benlate 50 WP	850 g	7	
captan	phthalimide	Maestro 75 DF	3.0–4.5 kg	2	
		Captan 80 W	2.75–4.25 kg	2	
		Supra Captan 80 WDG	2.75–4.25 kg	2	
metiram	dithiocarbamate	Polyram 80 DF	3.25 kg	7	

lesion nematode and *Verticillium* populations are high enough (see the section *Crop Rotation for Control of Diseases* on page 13).

Virus Disease (Mosaic, Streak, Gray Wall)

Grow seedlings in steamed soil in greenhouses and frames devoted to tomato seedlings only. Control aphids in seedbeds. Do not handle tobacco in any form when handling plants. Wash hands with soap and water before handling tomato plants. Do not harden transplants by leaving them in headlands or other weedy places. Cultivators should not be used in a healthy crop after use in an infected crop.

Blossom-End Rot (BER)

This disease is a deficiency of calcium in the blossom-end of the fruit that prevents proper development of that tissue. Drought conditions reduce the amount of water movement into the plant, thus reducing the movement of calcium to the fruit. Therefore, BER is caused primarily by drought, not by a deficiency of calcium in the soil. Side-dressing with calcium nitrate will not prevent BER if adequate moisture is not available.

Foliar sprays of calcium are also not effective, because most of the calcium is taken up and fixed in the leaves, and very little reaches the fruit.

Under drought conditions, growers should avoid deep cultivation, which can prune roots and reduce moisture uptake, making BER more severe. Blossom-end rot can be controlled by irrigation, which allows more movement of calcium into the plant. (See the section *Irrigation* on page 43.)

Insect Management

Variegated Cutworm

Chemical control is obtained only when insects come in contact with the insecticide. Control is therefore related to how effective the spray coverage is on the larvae. Early detection and control are essential, as larger insects are more difficult to control. Pheromone traps can be used to detect peak moth flights.

If monitoring indicates a need, spray with one of the pesticides recommended in Table 5–63, *Tomato Insect Control Recommendations,* on page 139.

Aphid

Control is needed infrequently. If monitoring indicates a problem, spray with one of the pesticides recommended in Table 5–63 on page 139.

Good spray coverage is required for aphid control. Repeated spray applications may be required when weather conditions favour rapid build-up of aphids. The two types of aphids affecting tomatoes are the potato aphid and the green peach aphid, the latter being more difficult to control. Control of aphids with diazinon and malathion has been inconsistent in many areas.

Tarnished Plant Bugs

If monitoring indicates a need, the materials recommended in Table 5–63 on page 139, are labeled for control of tarnished plant bug.

For more information, consult the OMAFRA Factsheet *Tarnished Plant Bug Damage on Vegetable Crops in Ontario,* Order No. 98-025.

Colorado Potato Beetle

Regular field scouting provides accurate information on the development and location of problem insect populations, increasing the effectiveness of foliar sprays. For example, young Colorado potato beetle larvae are much easier to control than adult beetles. Border sprays may provide adequate protection of new tomato fields from migrating Colorado potato beetles.

Warning: In a number of counties and regions, Colorado potato beetles have developed at least ten-fold resistance to a number of insecticides. To control Colorado potato beetles susceptible to insecticide, use one of the insecticides recommended in Table 5–63 on page 139 and repeat as necessary. To slow development of further resistance, it is essential for all growers to alternate insecticides, choosing from a different group each time a spray is applied.

Hornworm

If hornworms are present and monitoring indicates a need, spray with one of the pesticides recommended in Table 5–63 on page 139.

Drosophila (Fruit fly)

If monitoring indicates a need, in the field, apply one of the pesticides recommended in Table 5–63 on page 139.

On picked fruit, spray or dust fruit and containers with a commercial mixture containing pyrethrins and piperonyl butoxide at rates given on the label. This spray or dust is permitted on all types of tomatoes.

Cabbage Looper

If cabbage loopers are a problem, spray with one of the pesticides recommended in Table 5–63 on page 139.

Sap Beetle

Since there is no suitable insecticide to control sap beetles in the field, practise the following cultural controls to reduce the incidence of sap beetles in the fruit:

1. Make roadways in the field at suitable intervals to allow movement of farm vehicles.

2. Minimize crushing and squashing of fruit at picking time.

3. Pick as close as possible to time of delivery to the factory.

4. If loaded wagons are not delivered immediately, leave them exposed to air circulation rather than in a protected area.

Grasshopper and Cricket

Maintain weed-free borders and fencerows. If these insects are a problem, spray around the edge of the field with one of the pesticides recommended in Table 5–63 on page 139.

TABLE 5–63.
Tomato Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Variegated Cutworm					
permethrin	pyrethroid	Pounce 384 EC	180–260 mL	1	
methomyl	carbamate	Lannate SP	270–540 g	1	If many large larvae (2.5–3.0 cm) are found, use the higher rate. Minimum period for re-entry is 24 hours.
carbaryl	carbamate	Sevin XLR Li	1.25 L	2	
acephate	organophosphate	Orthene 75 SP	1.2 kg in 2,000 L of water	90	Based on 14,000 plants/ha. Transplanting water treatment only.
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	7	Spray in the evening and do not disturb the soil for 5 days.
Aphid					
diazinon	organophosphate	Diazinon 50 WP	1.0–1.75 kg	1	
		Diazinon 500 EC	1.1–1.7 L	1	
		DZN 600 EW	0.915–1.4 L	1	
dimethoate	organophosphate	Cygon 480 E	0.5–1.1 L	7	
		Lagon 480 E	0.5–1.0 L	7	
malathion	organophosphate	Malathion 25 W	2.75–4.25 kg	3	
		Malathion 500 E	1.25 L	3	Not effective below 18°C.
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.0–2.25 kg	2	
		Thiodan 4 EC	1.5–2.75 L	2	
		Endosulfan 50 W	1.1–2.25 kg	2	
		Thionex 400 EC	1.5–2.5 L	2	
methomyl	carbamate	Lannate SP	270–540 g	1	Minimum period for re-entry is 24 hours.
acephate	organophosphate	Orthene 75 SP	1.2 kg in 2,000 L of water	90	Based on 14,000 plants/ha. Transplanting water treatment only.
Tarnished Plant Bug					
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	7	Minimum period for re-entry is 24 hours.
dimethoate	organophosphate	Lagon 480 E	0.55–1.1 L	7	
carbaryl	carbamate	Sevin XLR Li	5.25–6.4 L	2	
Colorado Potato Beetle					
Transplant Treatment					
imidacloprid	chloronicotinyl	Admire 240 F	0.92–1.3 L		Applications can be made as a drench in the transplanting water or through application equipment set up exclusively to apply Admire. Consult label for details. Use only ONE application where CPB populations are high.
		Admire 240 F	7–10 mL per 100 m of row		
acephate	organophosphate	Orthene 75 SP	1.2 kg in 2,000 L of transplant water	90	Based on 14,000 plants/ha. Caution: temporary plant damage may occur on light sandy soils or if too high a rate is used.
Foliar Treatment					
azinphos-methyl	organophosphate	Guthion 240 SC	1.75 L	4	7 days between applications. Maximum of 4 applications per season. Minimum period for re-entry is 48 hours.
		APM 50 WP	0.85 kg	4	
		Sniper 240 E	1.75 L	4	
		Sniper 50 W Clean Pak	0.85 kg	4	
permethrin	pyrethroid	Pounce 384 EC	180–260 mL	1	
cypermethrin	pyrethroid	Cymbush 250 EC	140 mL	3	
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83–125 mL	7	Use the higher rate for larger instars or higher populations of larvae. Minimum period for re-entry is 24 hours.
Bacillus thuringiensis	microbial	Novodor FC	4.0–8.0 L	0	Field scouting is essential for timing of sprays.
imidacloprid	chloronicotinyl	Admire 240 F	200 mL	7	A maximum of 2 foliar spray applications at least 5 days apart may be made per season. Do not make a foliar application following a soil application of Admire in the same crop.

TABLE 5–63.
Tomato Insect Control Recommendations (Continued)

Common Name	Group	Trade Name	Rate per Hectare	Days to Harvest	Notes
Hornworm					
permethrin	pyrethroid	Pounce 384 EC	180–260 L	1	
carbaryl	carbamate	Sevin XLR Plus	2.5–5.25 L	2	
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.0–2.25 kg	2	
		Thiodan 4 EC	1.5–2.75 L	2	
		Endosulfan 50 W	1.1–2.25 kg	2	
		Thionex 400 EC	1.5–2.5 L	2	
Bacillus thuringiensis	microbial	Thuricide HPC	0.75–1.5 L	0	
		Dipel 2XDF	140–275 g	0	
azinphos-methyl	organophosphate	Guthion 240 SC	1.75–2.25 L	4	Minimum period for re-entry is 48 hours.
		APM 50 WP	0.85 kg	4	7 days between applications.
		Sniper 240E	1.75–2.25 L	4	Maximum of 4 applications per season.
		Sniper 50 W Clean Pak	0.85–1.1 kg	4	
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	7	Minimum period for re-entry is 24 hours.
Drosophila (fruit fly)					
diazinon	organophosphate	Diazinon 50 WP	1.75 kg	1	
		Diazinon 500 EC	1.1–1.7 L	1	
		DZN 600 EW	0.915–1.4 L	1	
naled	organophosphate	Dibrom EC	1.1 L	4	
azinphos-methyl	organophosphate	Guthion 240 SC	1.75–2.25 L	4	Minimum period for re-entry is 48 hours.
		APM 50 WP	0.85 kg	4	7 days between applications.
		Sniper 240 E	1.75–2.25 L	4	Maximum of 4 applications per season.
		Sniper 50 W Clean Pak	0.85 kg	4	
Cabbage Looper					
Bacillus thuringiensis	microbial	Thuricide HPC	2.0–4.25 L	0	Most effective against small larvae.
		Dipel 2XDF	275–550 g	0	
Grasshopper and Cricket					
azinphos-methyl	organophosphate	Guthion 240 SC	2.25 L	4	Minimum period for re-entry is 48 hours.
		Sniper 240 E	2.25 L	4	7 days between applications.
		Guthion 50 WP Solupak	0.85 kg	4	Maximum of 4 applications per season.

Chemical Fruit Ripening

Use ethephon (Ethrel) for uniform ripening and once-over harvest and to enhance ripening in the late cultivars or during late seasons. For best results, ethephon should be applied to fields in good condition; plants that are stressed (wilted or damaged by disease or insects) will not respond satisfactorily.

Ethephon is effective only on fruits that are mature green (i.e., when cutting fruit with a sharp knife, seeds should remain uninjured, protected by a gelatinous pulp). With most processing cultivars, the time of application is when the maximum number of fruit has reached the mature green stage; this occurs when 5–20% of the fruit is showing red colour development. Good spray coverage on fruit and foliage is essential for maximum effectiveness. Use 3.75–6.4 L in 30–500 L of water/ha. Use higher rates when day temperatures are below 18°C and also when plant growth is dense. If plants are under stress, avoid use of ethephon or apply it at reduced rates. Excessive rates of ethephon will cause defoliation, which will result in reduced fruit quality. Cool temperatures will delay colour development and extend periods between treatment and harvest. Generally, fruit is ready to harvest 14–21 days after treatment.

Ethrel is not registered for use on fresh market tomatoes!

Visit the vegetable page on the OMAFRA Web site at http://www.gov.on.ca/OMAFRA/english/crops/hort/vegetable.html

6. Weed Management for Vegetables

Principles of Integrated Weed Management

Integrated weed management (IWM) uses all available weed control options in the best possible way to manage weed populations. Such options include crop rotation, cover crops, intercropping, manipulation of nitrogen fertility, planting pattern, tillage systems, critical period of weed control, alternative weed management strategies in conservation tillage systems and economic thresholds. All these practices are components of an IWM system; none of these control measures on their own can be expected to provide acceptable levels of weed control. Therefore, instead of relying on only one particular method of weed control, an IWM system uses a combination of methods to control weeds. By following the principles of an IWM system, the grower can reduce the use of herbicides and at the same time achieve optimum economic returns.

Crop Rotation

Crop rotation involves alternating different crops in a systematic sequence on the same land. It is an important strategy for developing a sound, long-term weed control program. Weeds tend to thrive among crops with similar growth requirements; cultural practices that benefit the crop may also benefit the growth and development of the weeds. Monoculture — growing the same crop in the same field year after year —results in a build-up of weed species that are adapted to the growing conditions of the crop. When diverse crops are used in a rotation, weed germination and growth cycles are disrupted by the variations in cultural practices associated with each crop (tillage, planting dates, crop competition, etc.).

Cover Crops

The inclusion of cover crops such as rye, barley, oats, red clover, buckwheat and oilseed radish or overwintering crops like winter wheat or forages in the cropping system can suppress weed growth. Fast-growing crops or crops exhibiting allelopathic properties can also suppress weeds. Highly competitive crops may be grown as short-duration "smother" crops within the rotation. Cover crop residues on the soil surface will suppress weeds by shading and cooling the soil. When choosing a cover crop, consideration should always be given to how the cover crop will affect the succeeding crop.

Intercropping

Intercropping involves growing a smother crop between rows of the main crop. Intercrops are able to suppress weeds. However, the use of intercropping as a strategy for weed control should be approached carefully. Intercrops can greatly reduce the yields of the main crop if they compete for water or nutrients.

Nitrogen Fertility

Nitrogen fertilizer can affect the competition between crops and weeds and in the subsequent crops. For example, nitrate is known to promote seed germination and seed production in some weed species. Nitrogen fertilization may result in increased weed growth instead of increased crop yield. Selective placement of nitrogen in a band can favour the crop over the weed. Use of legume residues as opposed to chemical nitrogen fertilizer to supplement the nitrogen needs of the crop can enhance weed suppression. Legume residues release nitrogen slowly with less stimulation of unwanted weed growth.

Planting Patterns

Crop population, spatial arrangement and the choice of cultivar (variety) can affect weed growth. For example, studies have shown that narrow row widths and a higher seeding density will reduce the biomass of later-emerging weeds by reducing the amount of light available for weeds located below the crop canopy. Similarly, fast growing cultivars can have a competitive edge over the weeds.

Tillage System

Tillage systems alter the soil seedbank dynamics and depth of burial of weed seeds. Studies have found that almost 75% of the weed seedbank was concentrated in the upper 5 cm of soil in no-till fields. In the mouldboard plow system, however, the seedbank is more uniformly distributed over depth. Other conservation tillage systems are intermediate to these two systems.

Weed seedling emergence is often more uniform from shallowly buried weed seeds and may result in better weed control. Weed seeds closer to the soil surface are more likely to be eaten or damaged by insects, animals, other predators and disease-causing organisms.

Critical Period for Weed Control

An important concept in IWM systems is the critical period of weed control — an interval in the life cycle of the crop when it must be kept weed-free to prevent yield loss. (See Table 6–1, *Critical Period for Weed Control*, right.)

This concept helps in determining the most effective time for non-residual postemergent herbicide applications, and reduces the practice of season-long residual herbicides and unnecessary late applications of herbicides. The critical periods are defined relative to a crop growth stage to account for soil, weather and seasonal variations. The critical period is based on a yield loss of less than 5% due to weed interference. In other words, the crop has to be weed-free during these stages to prevent a yield loss of more than 5%.

If weeds have been controlled throughout the critical period, the weeds that emerge later will not affect yield and can be controlled prior to harvest with a harvest aid to burn down the weeds and desiccate the crop.

Season-long weed control is not necessary.

Herbicide Band Applications

Alternative methods of weed control are available for all tillage systems. Studies have shown that banding herbicides will increase profitability. For example, selective application of herbicides in 30-cm bands on 76-cm wide corn rows represented an approximate 60% reduction in total herbicide applied into the environment. When complemented with inter-row cultivation, weed control and crop yields were maintained with lower herbicide costs. Band applications may also be practical in some other vegetable crops.

Economic Thresholds

Weed economic thresholds help in determining if weed density and interference is sufficient to justify control measures, i.e., if the yield loss avoided is greater than the cost of weed control. The time at which weeds emerge relative to the crop is a major determinant of yield loss. Early weeds that emerge at the same time as the crop cause more yield loss than weeds emerging after the crop is established. For example, economic threshold studies conducted with redroot pigweed, ragweed and barnyardgrass have found that the time of weed emergence in relation to the crop stage is more important than weed density when evaluating weed control options. Crop yield loss depends on the relative time of weed seedling emergence.

TABLE 6–1.
Critical Period for Weed Control

Crop	Critical Period
Onions	Whole season
Carrots	3–6 weeks after emergence
Beets	2–4 weeks after emergence
Potatoes	4 weeks after planting
Fresh tomatoes	36 days after transplanting
Squash	early plantings compete better
Lettuce	3 weeks after planting
Pickling cucumbers	4 weeks after seeding
Seeded tomatoes	9 weeks after seeding
Early cabbage	3 weeks after transplanting
Sweet corn	4th–10th leaf tip

Corn tolerated a weed density of 4 plants/m of row when redroot pigweed emerged at the 6th-leaf stage of corn, but only 0.5 plants/m of row when they emerged at the 3rd-leaf stage of corn.

Critical periods and economic thresholds, however, do not apply in the same way to weeds, such as black nightshade, that may reduce the quality of the crop. In such cases, the economic threshold may be zero.

Other Considerations

Mechanical weed control also remains a viable and effective option for weed control for many vegetable crops. A variety of mechanical tools are available for use in a range of vegetables and can significantly reduce the use of herbicides.

Herbicide resistance is also a concern in Ontario, however, it is difficult to diagnose, because many factors can contribute to weed control failures. If application methods, unfavourable weather conditions or improper timing have been ruled out, then the possibility of resistance can be investigated. Consult a weed specialist and herbicide supplier to develop a comprehensive weed-control program to manage the problem.

For a more detailed summary of weed management, consult OMAFRA Publication 75, *Guide to Weed Control*.

Notes on Herbicides for Vegetables

Introduction

These notes should be considered with the recommendations given in the specific crop sections, starting on page 186. Additional information on use, toxicity and safety precautions is given here. With a few exceptions, the chemicals are listed under their common (generic) rather than their trade or product name. See Table 6–2, *Pesticides Used on Vegetable Crops in Ontario*, on page 167, to determine the corresponding common name for a particular trade name. For example, Table 6–2 indicates that the trade name AATREX has a common name of atrazine. Notes on AATREX will be listed under atrazine in this section.

2,4-D

Trade Names: 2,4-D AMINE, ESTEMINE (AMINE), ESTASOL (L.V.ESTER).
Chemical Family: Phenoxy.
Crop and/or Non-Crop Registrations: Asparagus.
Sensitive Weeds: Most broadleaf weeds and brush.
Uptake and Translocation: Readily absorbed through leaves or roots. Translocated primarily in phloem with the sugars but can also move with water in the xylem. Accumulation is primarily in the young, rapidly growing meristematic regions of roots or shoots.
Basis of Selectivity: Differences in interception, penetration, translocation, metabolism and sensitivity of active sites lead to greater activity on broadleaf weeds compared to grasses.
Application Methods: Postemergence (broadleaf weeds), stem-foliage or stem-basal (brush).
Residual Activity: Half-life in soil is usually not longer than 1 or 2 weeks during the growing season due to rapid decomposition by soil microorganisms.
Unique Characteristics: All weeds are more easily killed when growing rapidly in moist soil. Unfortunately, some broadleaf crops, garden and ornamental plants are as sensitive to 2,4-D as many weeds, and even a trace of the chemical as spray drift, vapour drift or contaminant in soil or water may cause serious damage. Even crops that can be sprayed safely can be sensitive at some stages of growth or at excessive application rates; thus label precautions should be followed carefully. Amines and esters are the most common formulations of 2,4-D. The esters are the most active and can be used at the lower rates and for brush control. Since vapour drift is a potential problem with the ester formulations, only the amines should be used on lawns or near gardens or susceptible crop areas. Low-volatile esters can be used by agriculturists or licenced applicators in areas where risk of damage to sensitive non-target vegetation is low. Recommendations are on the basis of acid equivalent; commercial products differ in their content of acid equivalent, which must be considered in determining the amount of product to use.

ADJUVANTS

(See 38-F DRIFT RETARDANT, AGRAL 90, AF-SURF, AMMOMIUM SULPHATE, AMIGO, ASSIST OIL CONCENTRATE, CANPLUS 441, CITOWETT PLUS, COMPANION, DEFOAMERS, DRIFT-CONTROL AGENTS, ENHANCE, FIGHTER F, HALT, KORNOIL, KORNOIL CONCENTRATE, LI700, MERGE, MINERAL OIL [NON-HERBICIDAL], MINERAL OIL/ SURFACTANT [NON-HERBICIDAL], NALCO-TROL, SIDEKICK, SURE-MIX, SYLGARD 309, SPRAY ADJUVANT DEFOAMER, XA OIL CONCENTRATE).

AGRAL 90

Type of Adjuvant: Non-ionic surfactant.
Chemical Composition: Nonylphenoxy polyethyoxyethanol 90%.
Registered Uses: For use with diquat, paraquat, glyphosate, imazethapyr, rimsulfuron, nicosulfuron/ rimsulfuron and for washing sprayer tanks and equipment.
Benefit: Improves chemical effectiveness.
Mode of Action: It is a wetting and spreading agent that improves coverage of spray mixes.
Mixing: Use 250–1,000 mL/1,000 L of spray as specified on label. Will mix with all types of water. Add AGRAL 90 to the spray mixture and agitate thoroughly.
Unique Characteristics: Do not exceed the recommended rates of AGRAL 90 as too much wetting agent can lead to loss of spray due to excessive runoff.

AG-SURF

Type of Adjuvant: Non-ionic surfactant.
Chemical Composition: Nonylphenoxy polyethyoxyethanol 92%.
Registered Uses: For use with glyphosate, imazethapyr and fluazifop-p-butyl.
Benefit: Improves chemical effectiveness.
Mode of Action: It is a wetting and spreading agent that improves coverage of spray mixtures.
Mixing:
For use with ROUNDUP: When applying the 2.5 L/ha of water, add AG-SURF at 0.5% (0.50 L/100 L water) to maintain adequate surfactant concentration.
For use with ROUNDUP to control annual grasses and broadleaf weeds for minimum or zero-till: Use 350 mL/ha plus ROUNDUP at 1.1 L/ha in 50–100 L/ha of clean water.
For use with FUSILADE 250 EC: Add 100 mL of AG-SURF for each 100 L of spray solution (0.1%). An anti-foaming agent may be required to reduce foaming.

Unique Characteristics: Do not exceed recommended rates of AG-SURF, as too much may reduce the effectiveness of the herbicide due to excessive runoff. Consult product label for full directions.

AMIGO

Type of Adjuvant: Surfactant.
Chemical Composition: 30% phosphate ester surfactant.
Registered Uses: For use with clethodim and clethodim tank mixes.
Benefit: Improves chemical effectiveness under varying environmental conditions.
Mode of Action: Improves spreading of spray droplets on the leaf surface and increases contact area. Enhances penetration of herbicide through the leaf cuticle layer.
Mixing: Half-fill spray tank with water and start agitation. Add the correct amount of herbicide, agitate and then add the correct amount of AMIGO with the remaining water. Continue to agitate.

AMITROLE

Trade Name: AMITROL-T, AMITROL 240.
Chemical Family: Triazole.
Crop and/or Non-Crop Registrations: Post-harvest in peas. Use in shelterbelts, non-crop areas, marshes and ditches.
Sensitive Weeds: Many annual and perennial broadleaf weeds and grasses including quack grass, dandelions, Canada thistle, sow-thistle, poison-ivy, poison-oak, toadflax, milkweed, hoary cress, leafy spurge, horsetail, cattail, honeysuckle, locust, ash and sumac.
Uptake and Translocation: Absorbed by foliage and roots. Translocates well in xylem and phloem. Accumulates in growing regions of plant.
Basis of Selectivity: Resistant plants metabolize amitrole more rapidly than sensitive plants and may have lower uptake as a result of leaf structure that reduces wetting and penetration.
Application Methods: Foliar postemergence application to actively growing plants. Good coverage is essential. If weeds are mature, it is advisable to cut them and then spray the regrowth. Do not disturb treated plants for at least 2 weeks after application. Do not make post-harvest application after October 1. For control of quack grass and Canada thistle, apply in spring or fall to actively growing plants 15–20 cm tall. Wait 10–14 days and then plough or disk.
Residual Activity: Approximately 2–4 weeks in moist, warm soil.
Unique Characteristics: Most crops are sensitive if contacted. Poor results may occur if spray coverage is inadequate, if plants are drought stressed or over-mature, or if heavy rains fall within 6 hours after application. Do not graze or plant to grain, peas, alfalfa or clover for 8 months after treatment. Do not graze spot-treated areas in pastures for 6 months following treatment.

AQUASHADE

Chemical Family: Water-soluble dyes.
Crop and/or Non-Crop Registrations: Contained golf course, farm and industrial ponds, fountains and aquariums.
Sensitive Weeds: Filamentous algae and certain aquatic weeds.
Uptake and Translocation: The dye filters wavelengths of sunlight reducing the light intensity.
Application Methods: May be added in a concentrated form from the shoreline or in a diluted form for larger areas. Make the application early in the growing season before algae and weed growth develop. Mechanical removal of heavy vegetation is recommended before applying Aquashade if fish are present in the pond.
Residual Activity: The effect lasts as long as the water keeps its blue colour. Additional Aquashade can be applied when the colour of the water fades or when the first new algae and weed growth is noticed.
Unique Characteristics: It has no direct chemical action and will therefore not harm fish.

ASSIST OIL CONCENTRATE

Type of Adjuvant: Mineral oil/surfactant (non-herbicidal).
Chemical Composition: 83% paraffin base mineral oil plus 17% surfactant blend.
Registered Uses: ASSIST OIL CONCENTRATE is registered for use with sethoxydim, BASAGRAN, bentazon/atrazine and atrazine.
Benefit: The use of ASSIST results in improved postemergence activity and a greater degree of consistency under varying environmental conditions. ASSIST will also aid in providing a faster weed kill.
Mode of Action: Reduces the evaporation of spray droplets on the leaf surface leading to a longer period for penetration. Improves penetration through the leaf cuticle layer. ASSIST also aids in spreading a spray droplet on the leaf surface so that it covers a greater surface area.
Mixing: Half-fill the spray tank with water and begin agitation. Add the desired amount of herbicide and continue filling. Add ASSIST last. After filling, continue agitation. Agitate thoroughly after any stoppage in spraying.
Unique Characteristics: May cause increased temporary topical burn to crop plants under hot, humid weather conditions.

ATRAZINE

Trade Names: AATREX, AATREX NINE-O, ATRAZINE 90W, ATRAZINE 80W, ATRAZINE 500, ATRAZINE 480.

Chemical Family: S-triazine.

Crop and/or Non-Crop Registrations: Sweet corn.

Sensitive Weeds: Will control a wide range of broadleaf weeds such as mustards, purslane, ragweed, smartweed, lady's-thumb, wild buckwheat, lamb's-quarters, pigweed and volunteer clover. Populations of lamb's-quarters, pigweed and ragweed have been found that are resistant to atrazine and are therefore not controlled.

Uptake and Translocation: Actively absorbed by roots and foliage, although foliar absorption is usually small. It is translocated to the top of the plant and accumulates in the leaf margins and the growing points.

Basis of Selectivity: Metabolism by tolerant species.

Application Methods: For corn, preplant incorporated, preemergence or postemergence (with or without oil) usually before the annual weeds are more than 4 cm high; under dry weather conditions, a shallow incorporation may enhance activity; oil or oil/surfactant blends will increase the postemergence activity. For lowbush blueberries, preemergence application. For triazine-tolerant canola, postemergence. Dry bulk fertilizer may be impregnated with atrazine and applied preplant incorporated. Atrazine may be tank mixed with several other annual grass and broadleaf herbicides to increase the spectrum of weed control in corn.

Residual Activity: Can persist in the soil for varying lengths of time depending on rate, weather and soil conditions (longer under dry, cool weather conditions and in sandy soils). Postemergence treatments tend to persist longer than preemergence treatments.

Unique Characteristics: Atrazine may carry over for more than one planting season. One year after application, there is usually no hazard to most rotational crops when 1.5 kg ai/ha or less is applied. Cool, dry weather and sandy soils are conditions under which problems may arise.

BENSULIDE

Trade Name: BETASAN, PREFAR.

Chemical Family: Benzenesulfonamide.

Crop and/or Non-Crop Registrations: Cucumbers.

Sensitive Weeds: Germinating annual grasses such as annual bluegrass, barnyard grass, crab grass and foxtail. Some control of redroot pigweed, lamb's-quarters and shepherd's-purse.

Uptake and Translocation: Adsorbed on root surfaces; a small amount is absorbed by the roots. Little or none is translocated upward to the leaves.

Basis of Selectivity: Inhibits root growth and partially inhibits cell division in sensitive seedlings. Sensitive species affected only in seedling stage. Metabolized by established grasses.

Application Methods: Preemergence in spring or fall for turf (well-established only); a higher rate is required for fall applications to control germinating weeds the following spring; incorporate by lightly irrigating into soil.

Residual Activity: Season-long weed control. Degraded slowly by soil microorganisms with a half-life of 4–6 months depending on soil type. Because of soil residues, only cucurbits, cole crops, carrots, lettuce, peppers and tomatoes should be planted the following year.

Unique Characteristics: Bensulide is inactivated in soils containing high amounts of organic matter (muck soils). Incorporation recommended to avoid photodecomposition. Do not reseed lawn within 1 year of application. Formulations available with fertilizers for homeowner lawn use.

BENTAZON

Trade Names: BASAGRAN FORTE, BASAGRAN.

Chemical Family: Benzothiadiazine.

Crop and/or Non-Crop Registrations: BASAGRAN FORTE AND BASAGRAN: Peas, sweet corn. BASAGRAN also registered for lima beans, snap beans.

Sensitive Weeds: Annual broadleaf weeds including hairy nightshade, lamb's-quarters, redroot pigweed, low cudweed, purslane, common ragweed, wild radish, Russian thistle, hairy galinsoga, corn spurry, bird rape, flower-of-an-hour, buttercups, common groundsel, jimsonweed, giant ragweed, velvetleaf, lady's-thumb, wild mustard, cocklebur, stinkweed, shepherd's-purse and common chickweed. Triazine-tolerant biotypes of lamb's-quarters, redroot pigweed, common ragweed and common groundsel are also controlled. Top growth of Canada thistle and nut sedge are controlled. Field bindweed may be suppressed by two applications applied 10 days apart.

Uptake and Translocation: Taken up through the foliage. Not translocated.

Basis of Selectivity: Metabolism by tolerant species.

Application Methods: Postemergence when weeds are small and actively growing. Apply in 100–400 L water/ha. Crop must be in a tolerant growth stage (see specific recommendations on label). Thorough spray coverage is necessary. Use flat fan nozzles tilted 45° forward. Use ASSIST OIL CONCENTRATE with BASAGRAN. The ASSIST rate should be reduced under hot, humid conditions. CITOWETT PLUS may replace ASSIST on peas. Liquid ammonium sulphate or 28% urea ammonium nitrate may be added to BASAGRAN FORTE or BASAGRAN for improved and more consistent control of velvetleaf and lamb's-quarters in soybeans

only. PINNACLE may be tank mixed with BASAGRAN FORTE or BASAGRAN for improved pigweed and lamb's-quarters control in soybeans only. BASAGRAN FORTE does not require additional adjuvants. BASAGRAN FORTE is not registered for aerial application. BASAGRAN is registered for aircraft application for soybeans, dry and snap beans.

Residual Activity: Essentially none.

Unique Characteristics: Corn and turf are tolerant at all stages of growth. Bentazon is not volatile. Temporary crop injury can be expected if bentazon is applied during hot, humid weather or if crop is stressed (flooding, drought, cold). Cool weather or drought may delay control. Rainfall within 6–8 hours after application may reduce effectiveness. Since there is no residual activity, a new flush of weeds may emerge after the first flush has been controlled.

BENTAZON/ATRAZINE

Trade Name: LADDOK.

Chemical Family: Benzothiadiazine/s-triazine.

Crop and/or Non-Crop Registrations: Sweet corn.

Sensitive Weeds: Annual broadleaf weeds such as black nightshade, redroot pigweed, lamb's-quarters, low cudweed, purslane, common ragweed, Russian thistle, corn spurry, flower-of-an-hour, lady's-thumb, wild mustard, hairy galinsoga, bird rape, buttercup, common chickweed, common groundsel, jimsonweed, giant ragweed, velvetleaf and cocklebur. Triazine-tolerant biotypes are also controlled. Top growth of Canada thistle and nut sedge are controlled. Field bindweed may be suppressed.

Uptake and Translocation: Uptake into the plant occurs primarily through the leaves. Bentazon/atrazine has mainly contact action, and translocation is minimal.

Basis of Selectivity: Metabolism by tolerant species.

Application Methods: Bentazon/atrazine should be applied early, postemergence when weeds are small and actively growing. Apply in 200–400 L water/ha. Application should be made before weeds reach the maximum size listed on the label. This generally corresponds to corn in the 1- to 5-leaf stage. Under good growing conditions, the most effective time for spraying will usually be 18–28 days after planting. ASSIST OIL CONCENTRATE should be added to the spray tank for all applications. Thorough spray coverage is important, and flat fan nozzles should be used. The use of flooding nozzles is not recommended because of inadequate coverage.

Residual Activity: Injury may occur to any crop other than corn planted in the same season on land treated with bentazon/atrazine. In the season after application, there is virtually no hazard to most rotational crops when label rates for annual weed control have been used. Overlap or the use of a double application for nut sedge control may result in injury to rotational crops due to carry over of the atrazine component of bentazon/atrazine.

Unique Characteristics: Corn is tolerant at all stages of growth. Rainfall within 6–8 hours of application may reduce the effectiveness of the spray solution. Bentazon/atrazine is not volatile but it should not be applied when the crop is under stress from prolonged cold, wet weather, poor fertility or other factors.

BROMOXYNIL

Trade Name: PARDNER.

Chemical Family: Hydroxybenzonitrile.

Crop and/or Non-Crop Registrations: Sweet corn, garlic.

Sensitive Weeds: Smartweed, nightshade, velvetleaf, pigweed, common ragweed, cocklebur, stinkweed and wild mustard are killed if the chemical thoroughly contacts these plants before they have more than 4 true leaves: wild buckwheat and lamb's-quarters control to 8-leaf. Most established perennial broadleaf weeds, chickweed and grasses tolerate field applications of this herbicide.

Uptake and Translocation: Absorbed by plant foliage and moves very little within the plant.

Basis of Selectivity: Differential spray retention, uptake, translocation and degradation.

Application Method: Postemergence.

Residual Activity: Essentially no soil residual activity.

Unique Characteristics: Crop injury symptoms (leaf scorch) may develop if the plant is under stress within 2–3 days before or after spraying; this stress could be caused by high temperatures or high humidity or, in the case of corn, application following a period of cool, wet weather; such injury usually does not affect yields. The formulation includes a wetting agent to improve the spread of droplets on the leaf. Although bromoxynil is not an effective soil-applied herbicide, broadleaf crops such as turnips, peas and beans should not be seeded for a week after spray application.

CANPLUS 411

Type of Adjuvant: Mineral oil/surfactant (non-herbicidal).

Chemical Composition: 83% paraffin-base mineral oil plus 17% surfactant blend.

Registered Uses: CANPLUS 411 is registered for use with ASSURE II.

Benefit: The use of CANPLUS 411 results in improved postemergence activity and a greater degree of consistency under varying environmental conditions.

Mode of Action: Reduces the evaporation of spray droplets from the leaf surface and decreases the surface tension

of spray droplets, thus improving the penetration through the cuticle of leaf surfaces.
Mixing: Add the required amount of water to spray tank with agitator running. Add ASSURE II and when well mixed add 5–10 L of CANPLUS 411 for each 1,000 L of spray solution.
Unique Characteristics: May cause increased temporary phytotoxicity to crop plants under hot humid weather conditions.

CHLORPROPHAM

Trade Names: CIPC EC, CIPC GR, CIPC.
Chemical Family: Phenylcarbamate.
Crop and/or Non-Crop Registrations: Carrots, lettuce, onions, spinach.
Sensitive Weeds: Annual broadleaf and grass weeds including purslane, chickweed, smartweed, carpetweed, false flax, annual bluegrass, crab grass, rye grass, stink grass and dodder.
Uptake and Translocation: Readily translocated to the leaves following root absorption. Vapours have been demonstrated to be absorbed by seeds and emerged dodder.
Basis of Selectivity: Rapid degradation in tolerant plants as well as soil adsorption.
Application Methods: Preemergence and directed postemergence in specified crops.
Residual Activity: Tightly bound to soil colloids. The rate of dissipation can vary greatly with microbial activity and moisture level. Both high soil temperature and excessive soil moisture increase the rate of dissipation.
Unique Characteristics: Use the lower rates on sandy or coarse-textured soils and the higher rates on clay or muck soils. Weed control is most effective when soil temperatures are below 16°C. The lower rate should be used when soil temperature is below 16°C. The soil must be moist for effective weed control.

CITOWETT PLUS

Type of Adjuvant: Non-ionic spreader sticker surfactant.
Chemical Composition: Octyl phenoxy poly polyethoxy ethanol 50%.
Registered Uses: Sugar beets and red beets/pyrazon; peas/bentazon.
Benefit: Improves postemergence control of weeds that have reached their upper limit in size for susceptibility.
Mode of Action: Causes the spray mix to form a continuous film on leaf surfaces; also makes herbicide more rainfast.
Mixing: Half-fill tank with water; add herbicide with continuous agitation; complete filling of tank with water; add CITOWETT with continuous agitation.
Unique Characteristics: Higher rates are required with hard water.

CLETHODIM

Trade Name: SELECT.
Chemical Family: Cyclohexanedione.
Crop and/or Non-Crop Registrations: Dry onions, potatoes.
Sensitive Weeds: Annual grasses (wild oats, green and yellow foxtail, volunteer cereals, volunteer corn and barnyard grass).
Uptake and Translocation: Uptake through the foliage and translocated through both the phloem and xylem throughout the plant accumulating in the meristemic regions both above and below the ground.
Basis of Selectivity: Tolerant plants rapidly metabolize clethodim to several conjugated metabolites.
Application Method: Postemergent to actively growing grasses in the 2- to 6 true-leaf stage.
Residual Activity: Rapid degradation in both soil and water with no soil activity.
Unique Characteristics: Highly active on all annual grasses and volunteer cereals at one low dose rate of 0.19 L/ha in a tank mix with the adjuvant CC-16255.

CLOPYRALID

Trade Names: LONTREL, LONTREL 360, TRANSLINE.
Chemical Family: Pyridine.
Crop and/or Non-Crop Registrations: Rutabagas, cole crops (cabbage, cauliflower, broccoli, asian cole crops).
Sensitive Weeds: Will control or suppress certain annual and perennial weeds including Canada thistle, goldenrod, ox-eye daisy, tufted vetch, sheep sorrel, dandelion and wild buckwheat, scentless chamomile, groundsel, ragweed, coltsfoot and spotted knapweed.
Uptake and Translocation: Rapidly absorbed by foliage and translocated readily throughout the plant via both xylem and phloem systems. Clopyralid is distributed throughout the plant to the meristem.
Basis of Selectivity: Effects on nucleic acid metaboiism and growth are not observed in grasses and other tolerant species.
Application Methods: Postemergence as a broadcast or selective foliar.
Residual Activity: Half-life in soil is less than 30 days under conditions that are favourable for microbial degradation. Little to no residual activity.
Unique Characteristics: Clopyralid has little to no activity on woody vegetation, except woody species of the legume family.

COPPER CITRATE AND GLUCONATE

Trade Name: ALGIMYCIN PLL-C.

Chemical Family: Chelates of copper gluconate and copper citrate.

Crop and/or Non-Crop Registrations: Algae control in wholly enclosed farm, fish and fire ponds having no outflow beyond the property limits of the user.

Sensitive Weeds: Most algae including Spirogyra, Ulothrix, Cladophora, Chara and Nitella.

Uptake and Translocation: No information available.

Basis of Selectivity: Non-selective.

Application Methods: Available as a tablet or a liquid formulation. Apply early in the season where algae is well established and growing vigorously. Apply early in the day as sunlight enhances the effectiveness of the treatment. To ensure even distribution, apply tablet formulation with a hand scoop. Apply liquid directly onto floating mats of algae or inject below surface for algae growing on the bottom of the pond, with a small hand sprayer or backpack sprayer. To avoid oxygen depletion, treat one-third to one-half of the water area in a single operation and wait at least 10–14 days between treatments.

Residual Activity: One application of the tablet formulation of ALGIMYCIN should provide control over the entire year. When using liquid ALGIMYCIN, a second treatment or spot treatment later in the season may be required.

Unique Characteristics: The tablet formulation is more effective than the liquid formulation for the control of Chara and Nitella. Not for use in public waters or waters that drain into public waters. Do not apply in deep waters. May be toxic to trout and other species of fish. Do not apply directly to crop plants, seedling grasses or non-established ornamental plants, as injury may result. Not for use in potable water systems.

COPPER ETHANOLAMINE

Trade Name: CUTRINE-PLUS.

Chemical Family: Mixture of chelates of copper ethanolamines.

Crop and/or Non-Crop Registrations: Algae control in wholly enclosed farm, fish and fire ponds and fish hatcheries having no outflow beyond the property limits of the user.

Sensitive Weeds: Microcystis, Oscillatoria, Anabaena, Aphanizomenon, Spirogyra, Cladophora, Vaucheria, Ulothrix, Chara and Nitella.

Uptake and Translocation: No information available.

Basis of Selectivity: Non-selective.

Application Methods: Available as a granular or liquid formulation. Apply early in the day as ample sunlight is required for maximum control. To ensure even distribution of the granular formulation, employ a scoop or dry fertilizer spreader. Use a hand or power sprayer for best distribution of the liquid formulation. To avoid oxygen depletion, treat only half-to-one-third of the pond at a time. Allow 1–2 weeks between treatments.

Residual Activity: One application of granular CUTRINE-PLUS should provide control over the entire season. When using liquid CUTRINE-PLUS, a second treatment later in the season may be required.

Unique Characteristics: Not for use in potable waters. Not for use in public waters or waters that drain into public waters. Extremely toxic to fish in soft waters; toxic in hard waters if the maximum recommended concentration is exceeded; if fish are present but water hardness is not known, do not use CUTRINE-PLUS. Treated areas may be used for swimming or fishing immediately after treatment. Water from treated pools may be used to irrigate turf, fairways, putting greens and ornamental plants.

CORNOIL

(See KORNOIL)

CORNOIL CONCENTRATE

(See KORNOIL CONCENTRATE)

CYANAZINE

Trade Names: BLADEX LIQUID, BLADEX 90DF.

Chemical Family: S-triazine.

Crop and/or Non-Crop Registrations: Sweet corn.

Sensitive Weeds: Annual nightshades, purslane, lady's-thumb, lamb's-quarters, prostrate knotweed, shepherd's-purse, wild buckwheat, wild mustard, wormseed mustard, velvetleaf, pigweed, crab grass, green foxtail, yellow foxtail, witch grass, fall panicum and barnyard grass.

Uptake and Translocation: Readily absorbed by roots and foliage. When absorbed by roots, it is translocated to the leaves.

Basis of Selectivity: Metabolism by tolerant crops.

Application Methods: Preplant incorporated in corn but only in mixtures with other corn herbicides; incorporation equipment should be set to work no deeper than 10 cm. Preemergence in corn; moisture is required for activation. Early postemergence in corn up to the 3-leaf stage (wettable granule). Early postemergence in triazine-tolerant canola (liquid formulation).

Residual Activity: Cyanazine has a relatively short residual life in the soil; from normal spring applications there is no carryover of the herbicide to the next growing season.

Unique Characteristics: Cyanazine is a short-lived triazine herbicide with flexible application time. Preemergence applications do not adequately control barnyard grass, fall panicum or pigweed under conditions that delay germination, such as low temperature or dry soil surface. Emerged velvetleaf will be controlled by the early postemergence application but subsequent

germinating velvetleaf will not be controlled. Cynazine is not recommended alone for use on heavy clay soil. Do not use on peat, muck soils, sandy soils or soils with less than 1% organic matter. Do not use the liquid formulation postemergence in corn. Do not add oil or surfactants other than as specified on the label. Cyanazine may be used in tank mixes and has been formulated with various other herbicides. See label for specifications.

CYCLOATE

Trade Name: RO-NEET.
Chemical Family: Thiocarbamate.
Crop and/or Non-Crop Registrations: Red beets, spinach, sugar beets.
Sensitive Weeds: Crab grasses, barnyard grass, foxtails, yellow nut sedge and some annual broadleaf weeds.
Uptake and Translocation: Uptake by seed, roots and hypocotyl with upward translocation to the growing tip.
Basis of Selectivity: Species differentiation due to enzymatic detoxification and seed food reserves permitting seedling to outgrow effect of chemical.
Application Methods: Preplant incorporated. To prevent chemical loss, incorporate immediately into the soil by setting the incorporation equipment (i.e., tandem disks, field cultivator with sweep teeth or vibrating shank S-tine cultivator) to work the soil approximately 10 cm deep followed by a levelling device. Irrigation (approximately 0.6 cm) can also be used to incorporate. When application and incorporation are done in separate operations, application should be to a dry soil surface.
Residual Activity: Season-long weed control with no soil residues the following year to prevent crop rotation.
Unique Characteristics: Does not need rainfall to activate and will not leach significantly under heavy rainfall. Under unfavourable germination conditions, leaf crinkling or leaf sealing may be observed, but usually without adverse effects on crop yield.

DAZOMET

Trade Name: BASAMID.
Chemical Family: Dithiocarbamate.
Crop and/or Non-Crop Registrations: Field and greenhouse vegetable seedbeds for eggplant, lettuce, pepper and tomato.
Sensitive Weeds: Most germinating weed seeds.
Uptake and Translocation: Breaks down on contact with soil moisture and releases toxic gases that control germinating weed seeds.
Basis of Selectivity: Non-selective. Chemical must be completely dissipated from the seedbed before planting or injury may occur. Breaks down on contact with soil moisture and releases toxic gases that control germinating weed seeds.
Application Methods: Apply granular product to a well-worked seedbed and incorporate evenly. Seal soil immediately after incorporation by rolling and flooding or by covering with heavy polyethylene plastic and sealing edges. After a waiting period of 10–40 days, depending on soil temperature, aerate the soil. Conduct a safety germination test before using treated soil. Do not use when soil temperature is below 6°C.
Residual Activity: Depends on the rate applied, soil moisture and soil temperature. The gases are toxic to all growing plants and a safety germination test must be carried out to determine that the soil is safe for planting.
Unique Characteristics: Also controls unencysted nematodes and soil fungi.

DEFOAMERS

(See FIGHTER F, HALT, SPRAY ADJUVANT DEFOAMER)

DESMEDIPHAM

Trade Name: BETANEX.
Chemical Family: Phenylcarbamate/Phenylcarbamate.
Crop and/or Non-Crop Registrations: Sugar beets.
Sensitive Weeds: Redroot pigweed, lamb's-quarters and wild mustard. Other weeds like ragweed species, wild buckwheat, nightshade species, kochia, goosefoot and stinkweed will be controlled when application of desmedipham is made following treatment with another preplant or preemergence herbicide.
Uptake and Translocation: Desmedipham is readily absorbed by foliage where it inhibits photosynthesis in the chloroplasts of leaf cells.
Basis of Selectivity: Rapid metabolism in tolerant species.
Application Methods: Postemergence beginning at the 2 true-leaf stage of sugar beets. Up to the 2- or 4-leaf stage of weeds depending upon species. Best control is exhibited on very small, actively growing weeds.
Residual Activity: Soil half-life of desmedipham is less than 1 month.
Unique Characteristics: Desmedipham may cause temporary growth retardation and/or chlorosis or tipburn to sugar beets when applied to stressed plants. Normal growth is resumed in 10 days after application.

DESMEDIPHAM/PHENMEDIPHAM

Trade Name: BETAMIX.
Chemical Family: Phenylcarbamate.
Crop and/or Non-Crop Registrations: Sugar beets.
Sensitive Weeds: Pigweed species, lamb's-quarters, wild mustard, wild buckwheat, green and yellow foxtail. Other weeds like ragweed species, nightshade species, kochia, goosefoot and stinkweed will be controlled when application of desmedipham/phenmedipham is made

following treatment with another preplant or preemergence herbicide.

Uptake and Translocation: Desmedipham/phenmedipham is readily absorbed by foliage where it inhibits photosynthesis in the chloroplasts of leaf cells.

Basis of Selectivity: Rapid metabolism in tolerant species.

Application Methods: Postemergence beginning at the 2 true-leaf stage of sugar beets. Up to the 2- or 4-leaf stage of weeds depending upon species. Best control is exhibited on very small, actively growing weeds.

Residual Activity: Soil half-life of desmedipham is less than 1 month and of phenmedipham is 25–30 days.

Unique Characteristics: Desmedipham/phenmedipham may cause temporary growth retardation and/or chlorosis or tip-burn to sugar beets when applied to stressed plants. Normal growth is resumed in 10 days after application.

DICLOFOP-METHYL

Trade Name: HOE-GRASS 284.

Chemical Family: Aryloxyphenoxypropionate.

Crop and/or Non-Crop Registrations: Potatoes, carrots, onions, snap beans, lima beans, peas.

Sensitive Weeds: Barnyard grass, foxtails, witch grass, fall panicum, wild oats, volunteer corn.

Uptake and Translocation: Primarily through the leaves. Does not translocate significantly.

Basis of Selectivity: Differential metabolism by tolerant vs. sensitive species.

Application Methods: Postemergence when grass weeds are in the 1- to 4-leaf stage.

Residual Activity: Essentially none.

Unique Characteristics: Tank mixtures with broadleaf herbicides will result in reduced weed control. A time interval of 4 days before or after an application of diclofop-methyl is required.

DIMETHENAMID

Trade Name: FRONTIER.

Chemical Family: Chloroacetamide.

Crop and/or Non-Crop Registrations: Sweet corn.

Sensitive Weeds: Green and yellow foxtail, barnyard grass, fall panicum, witch grass, large and smooth crab grass, redroot pigweed and eastern black nightshade.

Uptake and Translocation: Absorbed through shoots and roots of germinating grass and broadleaf weeds but primarily via plant coleoptile.

Basis of Selectivity: Not established.

Application Method:

1) Preplant incorporated: Incorporate with vibrating shank cultivator, harrow or other implement capable of giving uniform shallow incorporation into the top 5 cm of the soil within 7 days of planting;

2) Preemergence: Rainfall is required within 10 days of appliation to achieve sufficient herbicide activation;

3) Early postemergence: Apply at the spike to 2-leaf stage of corn and up to the 2-leaf stage of annual grass weeds.

Residual Activity: Provides season-long weed control. Length of residual activity depends upon soil and moisture factors, application rate and timing. Heavy rainfall following an incorporated treatment may reduce weed control.

Unique Characteristics: No recropping restrictions in the fall or spring application in corn or soybeans. Application flexibility; there are many tank mix and sequential treatment options for broad-spectrum weed control in corn and soybeans in all tillage systems (zero tillage to conventional tillage). Mixes well with bulk liquid and dry fertilizers.

DIQUAT

Trade Name: REGLONE.

Chemical Family: Bipyridylium.

Crop and/or Non-Crop Registrations: Vine killing of potatoes. Stale seedbed and inter-row weeding.

Sensitive Weeds: Any foliage contacted by diquat will be killed.

Uptake and Translocation: Rapidly absorbed by foliage. Limited translocation.

Basis of Selectivity: None.

Application Methods: Postemergence.

Residual Activity: Essentially none due to adsorption of chemical to soil particles.

Unique Characteristics: Must be used with clean (non-turbid) water as the soil particles in muddy water drastically reduce the effectiveness of diquat. Apply in weather conditions that will not promote drift. For aerial application, suggested conditions for good application are moderate temperatures (less than 25°C), humidity (greater than 40%) and wind (3.6–10 kph). Do not apply in dead calm conditions or when temperature inversion is likely (e.g., morning or evening when warm air is rising from crop). To avoid spray drift, use flat fan or hollow cone nozzles and a pressure of 140–210 kPa. For aerial application, point the nozzles back 130°–180°. For further information on aerial application, refer to the product label.

DIQUAT (AQUATIC)

Trade Name: REGLONE A.

Chemical Family: Bipyridylium.

Crop and/or Non-Crop Registrations: Aquatic weed control in still or flowing water in ponds, ditches, lakes and canals.

Sensitive Weeds: Coontail, Canada water weed, pondweeds, milfoil and duckweed.
Uptake and Translocation: Contact desiccant with limited translocation.
Basis of Selectivity: None.
Application Methods: Postemergence. Apply when weeds are visible and are actively growing. It can be applied with a boat bailer device that injects the chemical below the water surface; sprayed over the water surface; or poured directly from a container onto the surface.
Residual Activity: Quickly inactivated by adsorption to soil particles.
Unique Characteristics: Must be used with and applied on non-turbid water, as the soil particles in muddy water drastically reduce the effectiveness of the material. Apply at dusk. Do not use treated water for swimming or consumption by humans or animals for at least 24 hours. Do not use water for irrigation for 5 days after treatment. To avoid fish kills caused by oxygen depletion, treat only one-quarter to one-third of the area at a time. Avoid application or drift onto crops, lawns, grazing areas, ornamental plants and other desirable plants.

DIURON

Trade Name: KARMEX.
Chemical Family: Substituted urea.
Crop and/or Non-Crop Registrations: Asparagus.
Sensitive Weeds: Annual and perennial grasses, pigweed, ragweed, wild carrot and dandelion. Perennial weed control at higher rates in non-crop areas.
Uptake and Translocation: Most readily absorbed by roots, less so by foliage. Translocated upward in the xylem.
Basis of Selectivity: Used only in deep-rooted crops that are well established.
Application Methods: Applied to crops as a preemergence or directed, early postemergence spray, preferably before weed growth becomes dense. Better control of emerged weeds is obtained by the addition of a suitable surfactant. In non-crop areas, diuron may be sprayed anytime except when ground is frozen.
Residual Activity: At lower rates used in crops, residues last about a year and thus applications may be repeated annually. At higher non-crop rates, persistence may be more than 1 year.
Unique Characteristics: Should not be used where it is likely to leach or wash into contact with the roots of desirable trees or shrubs.

DRIFT-CONTROL AGENTS

(See NALCO-TROL.)

ENDOTHALL

Trade Name: DES-I-CATE.
Chemical Family: dicarboxylic acid.
Crop and/or Non-Crop Registrations: Vinekilling in potatoes.
Sensitive Weeds: N/A.
Uptake and Translocation: Absorbed through the roots and shoots of actively growing weeds.
Basis of Selectivity: Not established.
Application Method: See label.
Residual Activity: Very short, up to 7 days.
Unique Characteristics: High moisture after application is essential for the best control. Works very slowly.

EPTC

Trade Name: EPTAM.
Chemical Family: Thiocarbamate.
Crop and/or Non-Crop Registrations: Snap beans, potatoes.
Sensitive Weeds: Annual grasses such as crab grass, barnyard grass, fall panicum, wild oats, green foxtail and yellow foxtail; yellow nut sedge; some annual broadleaf weeds such as corn spurry, lamb's-quarters, nightshade, pigweed and chickweed if conditions are favourable for germination and growth.
Uptake and Translocation: Uptake by underground plant parts (roots, hypocotyl and seed). Upward translocation to the growing tip.
Basis of Selectivity: Metabolized by tolerant species at the seed germination stage through enzymatic breakdown of the chemical. Seed food reserves also permit seedling to outgrow chemical effect.
Application Methods: Preplant incorporated or postplant incorporated. May be applied using water or liquid fertilizers as the carrier. Dry fertilizers may also be used as a carrier when impregnated by licenced fertilizer dealers. To prevent chemical loss and reduce weed control, EPTC should be uniformly incorporated in the soil by setting the incorporation equipment (i.e., tandem disks, field cultivator with sweep teeth, or vibrating shank S-tine cultivator) to work the soil approximately 10 cm deep, followed by a levelling device. Irrigation (approximately 0.6 cm) can also be used to incorporate. When application and incorporation are done in separate operations, application should be a dry soil surface.
Residual Activity: Applied in the spring preplant, EPTC provides season-long weed control with no soil residues the following year to prevent crop rotation.
Unique Characteristics: EPTC does not need rainfall to activate and will not leach significantly under heavy rainfall. Under unfavourable germination conditions, leaf crinkling or leaf sealing may be observed on certain crops but usually without adverse effects on yield. May be tank

mixed with metribuzin for additional broadleaf weed control in potatoes. May be tank mixed with ethalfluralin or trifluralin for additional broadleaf weed control in beans (white, snap and kidney). See label for other tank mix combinations and information on less conventional methods of application.

EPTC/R25788 (EPTC+)

Trade Name: ERADICANE.

Chemical Family: Thiocarbamate.

Crop and/or Non-Crop Registrations: Sweet corn.

Sensitive Weeds: Annual grasses such as wild oats, crab grass, barnyard grass, foxtails, fall panicum; suppression of wild proso millet; yellow nut sedge, horsetail and some annual broadleaf weeds when conditions are favourable for germination and growth.

Uptake and Translocation: Uptake by underground plant parts (roots, hypocotyl and seed) then upward translocation to the growing tip.

Basis of Selectivity: Metabolized by tolerant species at the seed germination stage through breakdown of the chemical. R25788 enhances the enzymatic breakdown of the chemical in tolerant species. Also, seed food reserves permit corn seedlings to outgrow chemical effect.

Application Methods: EPTC/R25788 may be applied using water or liquid fertilizers as the carrier. Dry fertilizers may also be used as a carrier when impregnated by licenced fertilizer dealers. To prevent chemical loss and reduced weed control, EPTC/R25788 should be uniformly incorporated into the soil by setting the incorporation equipment (i.e., tandem disks, field cultivator with sweep teeth, or vibrating shank S-tine cultivator) to work the soil approximately 10 cm deep, followed by a levelling device. Irrigation (approximately 0.6 cm) can also be used to incorporate. When application and incorporation are done in separate operations, application should be to a dry soil surface and incorporation should be made within 4 hours of application. Preplant incorporated EPTC+ may be used in tank mix combination with 1) atrazine for additional broadleaf weed control or 2) metolachlor using reduced rates of both herbicides for more consistent control of many annual grasses.

Residual Activity: Provides season-long weed control with no soil residues the following year to prevent crop rotation. In tank mix combinations with atrazine, there may be atrazine residues when the highest atrazine rate is used.

Unique Characteristics: EPTC/R25788 does not need rainfall to be activated and will not leach significantly under heavy rainfall.

ETHOFUMESATE

Trade Name: NORTRON.

Crop and/or Non-Crop Registrations: Sugar beets.

Sensitive Weeds: Chickweed, lamb's-quarters, kochia, redroot pigweed, Russian thistle, wild buckwheat, barnyard grass, large crab grass, foxtails and downy brome.

Uptake and Translocation: Readily absorbed by emerging shoots (grass coleoptile and broadleaf hypocotyl) and roots, and translocated readily to the foliage. Postemergence applications of ethofumesate are poorly absorbed by maturing leaves with a well-developed cuticle.

Basis of Selectivity: Tolerant species conjugate the herbicide, rendering it inactive.

Application Methods: Preplant incorporated, preemergence.

Residual Activity: Half-life of less than 5 to more than 14 weeks depending on soil temperature and moisture conditions. Half-life increases in cooler, drier soils.

FENOXAPROP-P-ETHYL

Trade Name: EXCEL SUPER.

Chemical Family: Aryloxyphenoxypropionate.

Crop and/or Non-Crop Registrations:
EXCEL SUPER — Asparagus, broccoli, cabbage, cauliflower, carrots, onions (dry bulb only), peas (field and processing), potatoes, tomatoes.

Sensitive Weeds: Barnyard grass, green and yellow foxtail, crab grass, witch grass, wild proso millet, fall panicum, volunteer corn.

Uptake and Translocation: Uptake primarily through the leaves. Does not translocate significantly.

Basis of Selectivity: Differential metabolism by tolerant vs. sensitive species.

Application Methods: Non-residual postemergence for the control of annual grasses (EXCEL SUPER — 1- to 6-leaf stage). For best results, apply when weeds are young and actively growing. EXCEL SUPER — Do not apply if rainfall is expected within 1 hour of application.

Residual Activity: Essentially none.

Unique Characteristics: EXCEL can be tank mixed with BASAGRAN FORTE and/or PINACLE for broad-spectrum annual weed control in soybeans and dry beans only. If annual grasses are in the correct stage for application before broadleaf weeds have emerged, do not delay EXCEL SUPER application.

FIGHTER F

Type of Adjuvant: Antifoamer-Defoamer.

Chemical Composition: Dimethyl-polysiloxane 10%.

Registered Uses: To control foam in water, oil, fertilizer and pesticide spray mixtures.

Benefit: Controls foam when mixing sprays, eliminates material waste, provides more accurate metering of agricultural sprays and eliminates foam overflow at fill site.

Mixing: To control foam when mixing spray solution, add defoamer either just before or during addition of any other spray adjuvant. To cut existing foam, add defoamer to tank and recirculate solution until foam dissipates.

FLUAZIFOP-P-BUTYL

Trade Names: FUSILADE II.
Chemical Family: Aryloxy-phenoxypropionate.
Crop and/or Non-Crop Registrations:
FUSILADE II — Sugar beets, cabbage, broccoli, brussel sprouts, cauliflower, cucumber, onions, potatoes, rutabagas, tomatoes.
Sensitive Weeds: Annual grass species, volunteer corn, wheat, barley and quack grass.
Uptake and Translocation: Absorbed primarily by leaves. Translocated to roots and rhizomes.
Basis of Selectivity: Metabolism by tolerant species.
Application Methods: Postemergence. Apply when grasses are actively growing, and annual grasses are in the 2- to 5-leaf stage and quack grass is in the 3- to 5-leaf stage.
Residual Activity: Essentially none.
Unique Characteristics: Preplant tillage to break up rhizomes will improve control of quack grass. Except as noted on the label, broadleaf herbicides should be applied separately at least 3 days after fluazifop-p-butyl. Do not cultivate for 5 days after applying fluazifop-p-butyl. When plants are stressed (lack of moisture, excessive humidity, low temperature and/or very low relative humidity), fluazifop-p-butyl is less effective. Regrowth by tillering may occur if application is made under any of the above conditions. Since there is no residual activity, a new flush of weeds may emerge after the first flush has been controlled.

FOMESAFEN

Trade Name: REFLEX.
Chemical Family: Diphenyl ether.
Crop Registrations: Snap beans.
Sensitive Weeds: Redroot pigweed, common ragweed, wild mustard, lady's-thumb, black nightshade, cocklebur; suppression of velvetleaf, lamb's-quarters.
Uptake and Translocation: Taken up through foliage. Not readily translocated.
Mode of Action: Cell-membrane disrupter.
Method of Selectivity: Beans metabolize fomesafen. Some initial bronzing of crop leaves may occur, but plants normally outgrow this condition without any effect on maturity or yield.
Application Method: Early postemergence to weeds and crop. Apply when beans are 1–2 trifoliate and weeds are at the 2- to 4-leaf stage. Good coverage is essential for optimum weed control. Apply in 200–350 L of water/ha at a pressure between 245–420 kPa. Always add an adjuvant such as AGRAL 90 (0.25% v/v) or TURBOCHARGE (0.5% v/v).
Residual Activity: Persistence depends on weather and soil conditions (more persistent under dry conditions). Rotation to field corn, dry beans or soybeans the following year. Winter wheat may be planted 90 days after treatment. All other crops require a field bioassay.
Unique Characteristics: Do not apply REFLEX to any field more than once every 2 years.

FUMIGANTS

(See METAM SODIUM, METHYL-BROMIDE/CHLOROPICRIN, METHYL ISOTHIOCYANATE/DICHLOROPROPENE, METHYL ISOTHIOCYANATE/ DICHLOROPROPENE/CHLOROPICRIN)

GLUFOSINATE AMMONIUM

Trade Name: IGNITE, LIBERTY 200SN.
Chemical Family: Unique.
Crop and/or Non-Crop Registrations:
IGNITE — Potatoes; stale seedbed techniques in asparagus, carrots, lettuce and onions; ground crack application in potatoes.
LIBERTY 200SN — Corn hybrids specially developed to be tolerant to Liberty 200SN herbicide. Glufosinate-ammonium-tolerant inbred lines grown for seed corn production.
Sensitive Weeds: Non-selective, affects all actively growing green plants; regrowth of perennial species may occur.
Uptake and Translocation: Absorbed through foliage; minimal translocation; dependent on application rate and species treated.
Basis of Selectivity: IGNITE — All green plant tissue is sensitive; safe on mature (non-green) bark of woody plants. LIBERTY 200SN — All green plant tissue is sensitive except for field corn and seed corn plants that have been specially developed to be tolerant.
Application Methods: IGNITE — Postemergence; broadcast or directed spray to avoid contact with leaves or green bark of desirable plants; thorough coverage of the plant tissue to be controlled is essential. LIBERTY 200SN — Postemergence, broadcast 1- to 8-leaf stage.
Residual Activity: None; there are no cropping or rotational restrictions after application.
Unique Characteristics: Speed of action is influenced by environmental factors; at cool temperatures, poor moisture and low humidity, speed of action may be reduced. Heavy dew at time of application may reduce control of certain weed species.

GLYPHOSATE TMS

Trade Name: TOUCHDOWN 480. See glyphosate.

GLYPHOSATE

Trade Names: CLEAR-IT 1, CLEAR-IT 2, CLEAR-IT 3, EXPEDITE GRASS & WEED, E-Z-JECT, GLYFOS, LAREDO, RENEGADE, ROUNDUP, ROUNDUP DRY, ROUNDUP L & G, ROUNDUP TRANSORB, TOUCHDOWN 480, VISION, WRANGLER.

Chemical Family: Amino acid.

Crop Registrations:

GLYFOS, LAREDO, RENEGADE, ROUNDUP, ROUNDUP TRANSORB, WRANGLER — Preplant or post-harvest with no cropping restrictions. Preharvest in peas.

TOUCHDOWN 480 for preharvest use in **field peas**.

Non-Crop Registrations:

ROUNDUP — Asparagus.

Sensitive Weeds: Annual grasses; perennial weeds (quack grass, Canada thistle, sow-thistle, field bindweed, milkweed, cattails, nut sedge, poison-ivy etc.); brush (birch, alder, poplar, raspberry, willow and maple.

Uptake and Translocation: Absorbed through foliage and translocated throughout the plant.

Basis of Selectivity: Non-selective for agricultural crops. Conifers are tolerant at some stages, but the basis has not been established.

Application Methods: Postemergence, usually at the bud to bloom stage of growth for most perennial weeds. Canada thistle should be at least in early flower bud, milkweed at flower bud, and bindweed at full flower. Quack grass can be treated in the spring or fall when it is actively growing with at least 3–4 new leaves on each emerged shoot; in the fall, remove crop refuse but do not till prior to application; fall or spring tillage prior to spring application may reduce control; wait at least 3–5 days after application before working the area; for maximum control, it is advisable to till before the quack grass turns completely brown. Glyphosate can be applied with boom equipment, knapsack sprayers and high-volume equipment for agricultural and non-crop uses. Backpack mist blowers may be used for silvicultural site preparation and roadside brush control only. Aerial applications may be used for silvicultural site preparation and conifer release only. Can also be applied with selective equipment for non-crop areas, tree plantings, grapes and orchards. Regardless of method of application, do not allow herbicide solution to contact green foliage or green bark of crop or other desirable plants; remove all suckers from the trunks of desirable trees before spraying.

Residual Activity: None: crops can be planted or seeded directly into treated areas following application. Other herbicides are required to control weeds emerging after the application.

Unique Characteristics: Rainfall within 6 hours after application or heavy frost within 24 hours may reduce control. ROUNDUP TRANSORB is rainfast as soon as 4 hours after application.

GLYPHOSATE/GLUFOSINATE AMMONIUM

Trade Name: ROUNDUP FASTFORWARD PRESEED, ROUNDUP FASTFORWARD PREHARVEST.

Chemical Family: Amino acid/Unique.

Crop and/or Non-Crop Registrations:

ROUNDUP FASTFORWARD PRESEED — Preplant treatments with no cropping restrictions.

ROUNDUP FASTFORWARD PREHARVEST — Preharvest treatments in peas.

Sensitive Weeds: Annual grass and broadleaf weeds and many perennials such as quack grass and Canada thistle.

Translocation: Absorbed through foliage and translocated throughout the plant.

Basis of Selectivity: Non-selective for agricultural crops.

Application Methods: Postemergence to actively growing weeds using boom equipment (see glyphosate note for more information).

Residual Activity: None: Crops can be planted directly into the treated areas following application.

Unique Characteristics: Glyphosate/glufosinate ammonium provides quicker burndown of green vegetation than glyphosate alone. Rainfall within 2 hours after application or a heavy frost within 24 hours may reduce control.

HALT

Type of Adjuvant: Defoamer.

Chemical Composition: Silicone base, neutral.

Registered Uses: To reduce foaming when preparing herbicide spray mixes.

Benefit: The reduction of foaming allows faster tank fill-ups, ensures correct fill volumes, reduces the possibility of chemical overflow and gives more accurate herbicide application.

Mixing: Add 7 mL/500 L of spray mix. May be added to spray tank during filling to prevent foaming, or after to cut foam.

Unique Characteristics: May be used with any herbicide unless contraindicated on the label.

HERBICIDAL OIL

(See MINERAL OIL [HERBICIDAL].)

IMAZETHAPYR

Trade Name: CONQUEST B (Available only in CONQUEST co-pack), PURSUIT.

Chemical Family: Imidazolinone.

Crop and/or Non-Crop Registrations: Snap beans (Pursuit only), processing peas (Pursuit only).

Sensitive Weeds: Soil applications — green foxtail, yellow foxtail, old witch grass, barnyard grass, lamb's-quarters, redroot pigweed, smartweed, lady's-thumb, wild mustard, velvetleaf, common ragweed and reduced competition from eastern black nightshade and proso millet. Postemergence application — green foxtail, yellow foxtail, witch grass, barnyard grass, redroot pigweed, velvetleaf, wild mustard, cocklebur, eastern black nightshade, ragweed and reduced competition from proso millet, large crab grass, lamb's-quarter's, wild buckwheat and yellow nut sedge. Late postemergence application — green and yellow foxtail (up to 4-leaf stage), barnyard grass (up to 6-leaf stage), redroot pigweed (up to 12-leaf stage) and velvetleaf (up to 8-leaf stage).

Uptake and Translocation: Absorbed by both roots and foliage. Translocation in both xylem and phloem.

Basis of Selectivity: Metabolism by tolerant species.

Application Methods: Early preplant (up to 30 days before planting), preplant incorporated, preemergence and postemergence up to the 2-leaf stage of weeds, and late postemergence on specific weeds (see *Sensitive Weeds*, above).

Residual Activity: Persistence depends on weather and soil conditions (more persistent under dry conditions). Rotational cropping restricted to soybeans, white beans, kidney beans, processing peas, corn, spring barley, spring wheat and winter wheat. Do not plant other crops the year following application as injury may result.

Unique Characteristics: Can be applied up to 30 days prior to planting. Registered for use in reduced and no-till situations. Tank mixing is recommended for heavy infestations of ragweed or barnyard grass. Postemergence application requires the addition of AGRAL 90, AGSURF or ENHANCE surfactant and liquid fertilizer solution. Temporary soybean discoloration and/or shortening may occur with postemergence applications. A period of 100 days is required between application and planting winter wheat.

KORNOIL

Type of Adjuvant: Mineral oil (non-herbicidal).

Chemical Composition: 98.5% mineral oil, 1.5% emulsifier.

Registered Uses: Sweet corn and atrazine.

Benefit: Improved postemergence activity of atrazine.

Mode of Action: Partially dissolves waxy cuticle of weeds allowing atrazine to penetrate more readily.

Mixing: Fill spray tank with water allowing space for subsequent addition of atrazine and oil; engage agitation and pour in premixed slurry of atrazine in water; add KORNOIL last. Avoid excessive agitation of the spray mix as this may cause coagulation or buttering out.

Unique Characteristics: To prevent a build-up of oil in the sprayer, empty the tank as completely as possible before refilling. Some injury may occur if the crop is stressed (cold weather or hot, dry weather).

KORNOIL CONCENTRATE

Type of Adjuvant: Mineral oil/surfactant (non-herbicidal).

Chemical Composition: Paraffin-base mineral oil 85%, surfactant blend 15%.

Registered Uses: To be blended with atrazine/water mixtures and applied postemergence in corn.

Benefit: Improved postemergence activity of atrazine.

Mode of Action: Partially dissolves waxy cuticle of weeds allowing atrazine to penetrate more readily. Also reduces evaporation and aids in spreading of spray droplets on the leaf surface leading to a longer period for penetration.

Mixing: Avoid violent agitation; partially fill sprayer, add atrazine slurry, add KORNOIL CONCENTRATE last.

Unique Characteristics: Some injury may occur with cold, rainy weather.

LI700

Type of Adjuvant: Non-ionic surfactant and pH Adjuster/Acidifier.

Chemical Composition: Phosphatidylcholine, methylacetic acid and alkyl polyoxyethylene ether 80%.

Registered Uses: As a penetrating surfactant; as a pH adjuster/acidifier; for use with glyphosate products such as ROUNDUP, LAREDO, RENEGADE, WRANGLER and VISION. Alkaline water, even mildly alkaline, causes alkaline hydrolysis or degradation of many pesticides. Some chemicals degrade in less time than it takes to put out a tank of spray. When mixed with spray solutions, LI700 neutralizes or slightly acidifies the spray solution and prevents the breakdown hydrolysis of pH-sensitive products in the spray tank. Add LI700 before adding the pesticide.

Benefit: Improves chemical effectiveness.

Mixing: As a penetrating surfactant: Use 5 L of LI700/1,000 L spray mixture or 500 ml of LI700/100 L spray mixture. As a pH adjuster/acidifier for highly alkaline water, (pH 8 or higher), use 625 ml–1.25 L of LI700/1,000 L water mixture.

LINURON

Trade Name: AFOLAN F, LINURON 480, LOROX DF, LOROX L.

Chemical Family: Substituted urea.

Crop and/or Non-Crop Registrations: Sweet corn, carrots, celery, dill, parsnips, potatoes, asparagus.

Sensitive Weeds: Annual weeds such as barnyard grass, common chickweed, corn spurry, crab grass, velvetleaf, fall panicum, foxtail, goosefoot, goose grass, groundsel, knotweed, lamb's-quarters, redroot pigweed, purslane, common ragweed, shepherd's-purse, smartweed, stinkweed, wild buckwheat, witch grass, wormseed mustard, triazine-resistant weeds; seedlings only of dandelion, plantain and sow-thistle.

Uptake and Translocation: Readily absorbed through roots, less so through foliage; translocation primarily upwards in xylem.

Basis of Selectivity: Differencial metabolism often coupled with differential uptake and translocation.

Application Methods: Preemergence, postemergence, directed postemergence, pre plus postemergence.

Residual Activity: Does not pose a problem for subsequent crops since phytotoxic residues from applications at agricultural rates disappear within 4 months.

Unique Characteristics: Do not use on sandy or coarse-textured soils having less than 2% organic matter. If unusually heavy rains follow application, severe injury may occur to corn, soybeans, carrots and potatoes.

MALEIC HYDRAZIDE

Trade Name: ROYAL MH 60 SG.

Chemical Family: Unique.

Crop and/or Non-Crop Registrations: Sprout control in stored onions and potatoes.

Sensitive Weeds: Controls the growth of wild onion, garlic and biennial-type weeds such as dandelion and plantain when applied in the fall.

Uptake and Translocation: Absorbed through foliage. Translocated to active growing points in plant. Translocated more effectively downwards.

Basis of Selectivity: Not established.

Application Methods: Postemergence. Use as a foliar spray. Dosage and stage of plant development are critical factors. To reduce or eliminate mowing, apply in the spring or fall to green non-dormant grass; can be mixed with 2,4-D for spring applications. For tree and shrub growth control, apply to the portion of the plant on which growth is to be inhibited; growth control is best when applied to vigourous new growth; spray leaves and bark to point of run-off.

Residual Activity: None.

Unique Characteristics: Do not apply on or near crops being grown for seed. Rain within 24 hours after application will reduce effectiveness. Since temporary discoloration of grass may result, this chemical is recommended for use in areas where mowing grass is difficult and where lawn-like appearance is not necessary.

MCPB/MCPA

Trade Name: CLOVITOX PLUS, TROPOTOX PLUS.

Chemical Family: Phenoxy/phenoxy.

Crop and/or Non-Crop Registrations: Peas.

Sensitive Weeds: Small emerged mustards, stinkweed, ragweed, lamb's-quarters, redroot pigweed, shepherd's-purse, volunteer rapeseed, wild radish, hemp-nettle, annual sow-thistle; top-growth control of bull thistle, Canada thistle, curled dock, plantain, perennial sow-thistle, field bindweed, horsetail, buttercup.

Uptake and Translocation: Absorbed through the foliage and readily translocated, especially to the growing points.

Basis of Selectivity: MCPB is not directly toxic to plants. Susceptible weeds convert MCPB to MCPA.

Application Methods: Postemergence. In cereals, clovers and peas, apply as an overall spray. In corn, apply with drop pipes after the corn reaches 45 cm before the beginning of tasselling. Apply to pastures after grazing or cutting.

MERGE

Type of Adjuvant: Surfactant/solvent.

Chemical Composition: 50% surfactant blend plus 50% solvent (petroleum hydrocarbons).

Registered Uses: For use with sethoxydim.

Benefit: Improves chemical effectiveness and provides a greater degree of consistency under varying environmental conditions.

Mode of Action: Improves spreading of spray droplets on the leaf surface and increases contact surface area. Improves penetration of herbicide through the leaf cuticle layer. Acts as a protectant against photodegradation of sethoxydim by UV light.

Mixing: Half-fill spray tank with water, start agitation. Add required amount of herbicide and continue agitation. Add MERGE, along with remaining water, last to the tank. Agitate thoroughly after any stoppage in spraying.

Unique Characteristics: May cause temporary topical burn to crop plants under hot, humid weather conditions.

METAM SODIUM

Trade Name: BUSAN, VAPAM

Chemical Family: Thiocarbamate.

Crop and/or Non-Crop Registrations: Field and greenhouse seedbeds. Field-replant sites of vegetables.

Sensitive Weeds: Most scarified weed seeds and freshly vegetative parts including rhizomes and germinating seedlings.

Basis of Selectivity: Most plant parts are sensitive. Crops are not planted until all fumigant has dissipated from the soil. With moisture, methyl isothiocyanate gas is released, which kills most scarified seeds and fleshy vegetative parts including rhizomes and germinating seedlings.
Application Methods: Apply uniformly using injectors, water or other incorporation tools to carry the product to the desired soil depth. May be applied via the irrigation system. No gas-proof cover is required unless the soil is very porous, however, a sprinkler application of water should be used to provide a surface "water seal."
Residual Activity: 10–40 days depending on soil temperature and the amount of organic matter present in the soil. Persistence is greatest at low temperatures and high levels of organic matter. Planting may take place 12–16 days after the treatment and following a lettuce-seedling bioassay that indicates no injury.
Unique Characteristics: Also controls nematodes, soil fungi and soil insects. All traces of toxic gases must be dissipated from the treated soil before planting or plant injury may occur.

METHYL BROMIDE/CHLOROPICRIN

Trade Name: TERR-O-GAS 67.
Chemical Family: Organohalogen.
Crop and/or Non-Crop Registrations: Greenhouse seedbeds.
Sensitive Weeds: Gas is toxic to germinating seedlings.
Application Methods: Formulated as a liquid under pressure, that, when released from the container, forms a gas. Soil must be sealed with a plastic sheet since the gas is highly volatile. Refer to label for detailed directions.
Unique Characteristics: Methyl bromide gas is highly volatile and highly poisonous to humans and livestock. It may be absorbed by inhalation, ingestion and skin contact. A permit must be obtained from the Ontario Ministry of the Environment each time it is used. Also controls soil insects, nematodes and fungal diseases.

METHYL ISOTHIOCYANATE/ DICHLOROPROPENE

Trade Name: VORLEX PLUS.
Chemical Family: Thiocarbamate.
Crop and/or Non-Crop Registrations: Preplant treatment in both field and greenhouse soils to be planted to vegetables such as celery, lettuce, beets, tomatoes, eggplant, beans, melons, onions, asparagus, potatoes and squash; field crops such as sugar beets.
Sensitive Weeds: All growing weed seedlings within the fumigated zone. Non-germinated seeds or established weeds may not be controlled.
Basis of Selectivity: Non-selective. Gas is toxic to most young, green plant tissues.
Application Methods: Injected into the soil 15–20 cm deep using special application equipment. The soil surface is sealed by either surface irrigation or physically compacting the soil surface. Cultivation of the fumigated soil after the desired period of time allows the gas to escape.
Residual Activity: Varies with soil type but usually 4–6 weeks if left undisturbed. Aways check the soil for fumigant using the lettuce-seedling bioassay before planting a crop in it.
Unique Characteristics: Also controls fungal diseases and unencysted nematodes.

METHYL ISOTHIOCYANATE/ DICHLOROPROPENE/ CHLOROPICRIN

Trade Name: VORLEX PLUS CP.
Unique Characteristics: Chloropicrin provides added disease control to the mixture. See notes on METHYL ISOTHIOCYNANATE/ DICHLOROPROPENE.

METOBROMURON

Trade Name: PATORAN FL.
Chemical Family: Substituted urea.
Crop and/or Non-Crop Registrations: Lima beans, snap beans, potatoes.
Sensitive Weeds: Annual broadleaf weeds (including triazine-tolerant biotypes) such as pigweed, lamb's-quarters, green smartweed, ragweed, lady's-thumb, shepherd's-purse, annual nightshades, cudweed, corn spurry, groundsel, purslane, chickweed, mustards and stinkweed. Some activity on annual grasses such as barnyard grass, crab grass, green foxtail, witch grass, annual bluegrass and stink grass. The annual grasses are the first to escape treatment.
Uptake and Translocation: Absorbed through the roots. Translocated in the transpiration stream to the leaves where it accumulates at the margins.
Basis of Selectivity: Achieved through differential interception of the herbicide. Metobromuron must be placed on the soil surface and moved into the zone of germinating weed seeds but not come in contact with the roots of the germinating crop plants.
Application Methods: Preemergence. For beans, apply before the beans and weeds emerge; beans should be planted 4–5 cm deep; shallow-planted crops may be injured; do not use on soils with less than 2% organic matter; optimum organic levels are 2–5%. For potatoes, metobromuron should be applied at ground crack after the first hilling, provided the soil completely covers the emerged potato tips.
Residual Activity: Relatively short (6–8 weeks).
Unique Characteristics: Moisture is required for distribution into the top layer of soil where weed seeds are

germinating. Soil residues do not carry over to affect subsequent crop rotations.

METOLACHLOR

See S-METOLACHLOR

METOLACHLOR/ATRAZINE

See S-metolachlor/atrazine

METRIBUZIN

Trade Names: CONQUEST A (Available only in CONQUEST co-pack), LEXONE DF, SENCOR 500 F, SENCOR 75 DF, SENCOR SOLUPAK.
Chemical Family: S-triazine.
Crop and/or Non-Crop Registrations: Established asparagus, potatoes, transplant tomatoes.
Note: Conquest not registered for vegetables.
Sensitive Weeds: Lamb's-quarters, wild mustard, redroot pigweed, common ragweed, shepherd's-purse, lady's-thumb, velvetleaf, jimsonweed, prostrate pigweed, Russian thistle, yellow wood-sorrel, prickly mallow, chickweed, cocklebur, carpetweed, dandelion seedlings, barnyard grass, crab grass, foxtail, fall panicum, witch grass, Johnson grass seedlings and cheat grass.
Uptake and Translocation: Some uptake through the foliage but the major route is via the roots. Translocation upwards in the xylem.
Basis of Selectivity: Degradation by tolerant species.
Application Methods: Preplant incorporated (potatoes, soybeans, apples, apricots, peaches, cherries, corn, tomatoes and triazine-tolerant canola); preemergence (asparagus, potatoes, soybeans and triazine-tolerant canola); postemergence (potatoes, tomatoes, corn and triazine-tolerant canola).
Residual Activity: Varies with the climate. At normal-use rates, the half-life is 1–2 months.
Unique Characteristics: Heavy rainfall following application may cause crop damage. Some varieties of potato, soybean and tomato are less tolerant than others. Triazine-resistant weeds are not controlled. Do not use on muck soils.

MINERAL OIL (HERBICIDAL)

Trade Name: AGRICULTURAL WEED KILLER NO. 1.
Chemical Family: Aliphatic and aromatic hydrocarbons.
Crop and/or Non-Crop Registrations: Carrot, celery, dill, parsley, parsnips.
Sensitive Weeds: Annual weeds with the exception of ragweed, wormweed and wild carrot.
Uptake and Translocation: Absorbed by foliage. Little or no translocation.
Basis of Selectivity: Low-interception species such as the *Umbelliferae* family are tolerant.
Application Methods: Postemergence; broadcast or banded. For carrots, dill, parsley and parsnips, apply as soon as true leaves develop and before roots are thicker than a pencil. For celery, apply as soon as true leaves develop. Weeds should be less than 10 cm tall. Best results will be obtained if spray is applied on cool, sunny mornings; do not apply when excessively hot.
Residual Activity: None.
Unique Characteristics: Do not apply within 30 days of harvest as late application may flavour the harvested crop.

MINERAL OIL

(NON-HERBICIDAL) (see KORNOIL)

MINERAL OIL/SURFACTANT (NON-HERBICIDAL)

(See ASSIST OIL CONCENTRATE, CHARGE OIL CONCENTRATE, KORNOIL CONCENTRATE, XA OIL CONCENTRATE)

MONOLINURON

Trade Name: AFESIN.
Chemical Family: Substituted urea.
Crop and/or Non-Crop Registrations: Lima beans, snap beans, potatoes.
Sensitive Weeds: Particularly effective on most annual broadleaf weeds including triazine-resistant biotypes. Some activity on annual grasses but these will be the first to escape. Cultivation may be required.
Uptake and Translocation: Uptake is primarily through the roots of germinating weed seedlings, although leaf uptake is possible. Translocated upwards in the xylem to the shoots.
Basis of Selectivity: Monolinuron is placed on the soil surface and moves down into the zone of germinating weed seeds but not deep enough to come in contact with the roots of germinating crop plants.
Application Methods: Preemergence. For beans, apply before the beans and weeds emerge; beans should be planted 4–5 cm deep; shallow-planted crops may be injured; do not use on soils with less than 3% organic matter. On potatoes, apply preemergence or when plants are covered by hilling.
Residual Activity: Relatively short, 4–6 weeks.
Unique Characteristics: Moisture is required for distribution into the top layer of soil where weed seeds are germinating.

NALCO-TROL

Type of Adjuvant: Drift-control agent.
Chemical Composition: Polyvinyl polymer.

Registered Uses: For use with 2,4-D ester or amine, picloram, paraquat, simazine or dicamba for weed or brush control in non-crop land.
Benefit: Reduces drift, improves canopy penetration and foliage coverage.
Mode of Action: Reduces spray break-up and thus the number of fine, driftable droplets.
Mixing: Use 3–1,000 mL/1,000 L, depending on pressure, height and nozzle type. Add water and, while agitating, add NALCO-TROL before adding liquid herbicides. Add wettable-powder herbicides to water and ensure dispersion before adding NALCO-TROL.
Unique Characteristics: Product is extremely slippery; care should be taken when working on spray equipment and following a spill.

NAPROPAMIDE

Trade Names: DEVRINOL 50 DF, DEVRINOL 50W, DEVRINOL 10G.
Chemical Family: Amide.
Crop and/or Non-Crop Registrations: Asparagus, basil, cole crops (cabbage, broccoli, cauliflower, Chinese broccoli, Chinese mustard greens, Chinese Nappa cabbage, Chinese radish), garlic, kohlrabi, peppers, pumpkin, squash, fuzzy squash, rutabagas, tomatoes.
Sensitive Weeds: Many annual weeds including crab grass, barnyard grass, annual bluegrass, foxtails, sandbur, wild oats, goose grass, chickweed, groundsel, redroot pigweed, lamb's-quarters, purslane, prostrate knotweed, pineappleweed and prickly lettuce.
Uptake and Translocation: Absorbed through the roots of germinating weeds. Translocated upward through seedling.
Basis of Selectivity: Metabolized by tolerant species. Root growth of germinating seedlings is inhibited. Established plants are not affected due to placement selectivity.
Application Methods: May be applied preplant incorporated using water as the carrier. Incorporation should be uniform, and to a chemical depth of 2.5–5 cm, using irrigation or proper incorporation equipment (e.g., tandem discs or field cultivator with sweep teeth) followed by a levelling device. On established crops, apply to a weed-free soil surface and irrigate in if no rainfall occurs within 7 days after application in spring or fall, or within 2 days after application in summer; irrigate with sufficient water to wet the soil to a depth of 5–10 cm (approximately 7 mm of rain). For post-plant application in tobacco, apply in 25 cm band over the row. Cross-disc or cross-plough after harvest to dilute soil residue before planting cover crop.
Residual Activity: Provides season-long weed control if properly incorporated. Deep ploughing will minimize any carryover effect.
Unique Characteristics: Will not control germinated weeds. Resists leaching. To avoid injury to crops not registered for use with napropamide, do not plant until 12 months after the last napropamide application.

NAPTALAM

Trade Name: ALANAP-3.
Chemical Family: Amide.
Crop and/or Non-Crop Registrations: Cucumbers, melons, squash and pumpkins.
Sensitive Weeds: Seedlings of bindweed, chickweed, cocklebur, lamb's-quarters, pigweed, purslane, ragweed, velvetleaf, crab grass and foxtail.
Uptake and Translocation: Inhibits seed germination and may be absorbed through the root system after germination.
Application Methods: Preemergence. Soil clods should be thoroughly broken up and pulverized to give a smooth surface before spray applicaton. Apply up to 48 hours after planting. Following applications, the soil should not be disturbed unless later weed growth makes cultivation necessary. A second application may be applied to cucumbers and melons about 1 month after the first spray, when the crop has emerged but before the weeds are up. Use lower rates on light soil, higher rates on heavy soil.
Residual Activity: Completely decomposes in 6–8 weeks.
Unique Characteristics: Do not apply during very wet, cold weather as stunting of the crop may result. Avoid spray drift to areas planted to sensitive crops such as beets, tomatoes and spinach.

NICOSULFURON

Trade Name: ACCENT.
Chemical Family: Sulfonylurea.
Crop and/or Non-Crop Registrations: Certain varieties only of sweet corn. Not for use on seed corn.
Sensitive Weeds: Quack grass, proso millet, green and yellow foxtail, fall panicum, barnyard grass, old witch grass.
Uptake and Translocation: Following foliar absorption, nicosulfuron is rapidly absorbed through the leaves and translocated in both xylem and phloem.
Basis of Selectivity: Inhibition of acetolactate synthase (ALS) enzyme in susceptible plants leads to a rapid cessation of cell division and regrowth. Tolerant species rapidly convert nicosulfuron to non-phytotoxic metabolites.
Application Method: Postemergent within the 1- to 8-leaf stage of corn.
Residual Activity: No soil residual activity.
Unique Characteristics: Emerged grasses will be controlled by nicosulfuron but subsequent germinating grasses will not be controlled. A non-ionic surfactant must be added at 0.2% v/v. Typical symptoms of plant death (chlorosis, necrosis) occur 5–10 days after applica-

tion, depending on growing conditions. Do not apply to corn that has been treated with an organophosphorus soil insecticide (i.e., COUNTER, LORSBAN, THIMET, CYGARD or DI-SYSTON).

OIL

(See MINERAL OIL).

OXYFLUORFEN

Trade Name: GOAL.
Chemical Family: Diphenyl ether.
Crop and/or Non-Crop Registrations: Onions.
Sensitive Weeds: Purslane, pigweed, annual nightshades, wild buckwheat, lamb's-quarters.
Uptake and Translocation: Primarily foliar absorption but some root absorption. Very little movement within the plant following foliar or root absorption.
Application Methods: Postemergence. Best control is obtained when weeds are in the 2- to 4-leaf stage and actively growing. The first application can be made when onions have 2 fully developed true leaves. Repeat applications may be necessary to control late-germinating weeds. Use at least 500 L of water/ha.
Residual Activity: Limited preemergence activity.
Unique Char acteristics: Use on dry bulb onions. Do not use when crop or weeds are under stress. Do not apply within 56 days prior to harvest.

PARAQUAT

Trade Name: GRAMOXONE.
Chemical Family: Bipyridylium.
Crop and/or Non-Crop Registrations: Stale seedbed technique for vegetables; inter-row directed chemical weeding for vegetable fields; asparagus; potatoes; aquatic weed control.
Sensitive Weeds: Non-selective — affects all green plants.
Uptake and Translocation: Absorbed by foliage and green bark; little or no translocation.
Basis of Selectivity: All green plant tissue is sensitive. Less effective on plants with a very waxy cuticle and linear leaf shape such as nut sedge. Safe on mature (non-green) bark of woody plants.
Application Methods: Postemergence. Broadcast or directed spray to avoid contacting leaves or bark of desirable plants. Apply when weeds are less than 15 cm high. Better results are usually obtained if application is made on a dull or cloudy day, or in the evening.
Residual Activity: Essentially no residual activity in soil. Will persist in organic material such as mulches or turf thatch; therefore, do not reseed these areas for 5 days. More than one application per season may be necessary, especially for perennial weeds.
Unique Characteristics: Inactivated by adsorption to soil particles. Not available to homeowners. For a domestic registration, see paraquat/diquat.

PENDIMETHALIN

Trade Name: PROWL.
Chemical Family: Dinitroaniline.
Crop and/or Non-Crop Registrations: Onions.
Sensitive Weeds: Green foxtail, yellow foxtail, crab grass, barnyard grass, fall panicum, common chickweed, lamb's-quarters and pigweed.
Uptake and Translocation: Weeds are controlled as they germinate. Translocation is not significant, and emerged weeds are not controlled.
Basis of Selectivity: No significant uptake or translocation by the crop.
Application Methods: Onions: postemergence to the crop at loop and 2-leaf stage. Field corn: preemergence and early postemergence. For preemergence application, pendimethalin may be applied in water or liquid fertilizer. A fertilizer compatibility test should be carried out using pendimethalin and any of its registered tank mix partners. Early postemergence application may only use water as a carrier.
Residual Activity: Persistence depends on weather conditions (more persistent under dry conditions). Only registered crops may be planted in the year of application. Soybeans and corn may be planted the year following application in corn. Days to harvest restriction: 100 days.
Unique Characteristics: Strongly adsorbed to soil particles. Most effective when rain is received within 7 days of application. For onions, application at both growth stages is required for season-long control. Tank mixes in corn or sequential application of other herbicides in onions and corn are required for broad-spectrum weed control. Registered for dry bulb onions grown on muck soil only. DO NOT graze treated fields or feed treated foliage to livestock prior to 100 days after PROWL application.

PHENMEDIPHAM

Trade Name: SPIN-AID.
Chemical Family: Phenylcarbamate.
Crop and/or Non-Crop Registrations: Red (table) beets.
Sensitive Weeds: Lamb's-quarters, wild buckwheat, green foxtail, yellow foxtail, mustard.
Uptake and Translocation: Phenmedipham is absorbed by the leaves where it acts by inhibiting the Hill reaction in the chloroplasts of leaf cells.
Application Method: Postemergence.
Residual Activity: Half-life of phenmedipham is approximately 25 days.
Unique Characteristics: Phenmedipham may injure beets that are under stress. It may cause temporary growth

retardation and/or chlorosis or tip-burn on red beets. Beets usually resume normal growth within 10 days.

PROMETRYNE

Trade Name: GESAGARD
Chemical Family: S-triazine.
Crop and/or Non-Crop Registrations: Carrots, peas, leeks, and transplanted celery.
Sensitive Weeds: Lamb's-quarters, lady's-thumb, corn spurry, pigweed, wild mustard, purslane, eastern black nightshade, chickweed, hemp-nettle and green foxtail.
Uptake and Translocation: Absorbed through foliage and roots. Translocated upwards through xylem, accumulating in the apical meristems.
Basis of Selectivity: Metabolized by tolerant plants and to a lesser extent by sensitive plants, although this is not thought to be the major selective mechanism.
Application Methods: Preemergence or early postemergence (before weeds are 5 cm high). Apply before carrots or peas emerge. Apply 7–14 days after celery is transplanted.
Residual Activity: About 6–8 weeks. A fall cover crop of rye or oats may be sown on the treated land in the same season.

PROPYZAMIDE

Trade Name: KERB.
Chemical Family: Amide.
Crop and/or Non-Crop Registrations: Lettuce.
Sensitive Weeds: Perennial grasses including quack grass, annual grasses, volunteer cereals and common chickweed.
Uptake and Translocation: Taken up by plant roots and translocated to the foliage. Little foliar absorption.
Basis of Selectivity: Faster degradation in tolerant species.
Application Methods: Preemergence to annual weeds. Postemergence control of perennial grasses when applied in the fall. Apply in the fall from late September to early November when the soil temperature is low but above freezing, and soil moisture is high.
Residual Activity: Persistence is variable (2–9 months), depending on soil type and climatic conditions. Decomposition of the herbicide is slow at temperatures below 15°C but accelerates at temperatures above this level. Persistence is greatest in sandy soils with low organic matter.
Unique Characteristics: Rainfall or irrigation is required after application to move the herbicide into the root zone for uptake by perennial grasses and germinating annual grasses.

PYRAZON

Trade Name: PYRAMIN FL.
Chemical Family: Pyridazinone.
Crop and/or Non-Crop Registrations: Sugar beets and table beets. With NORTRON on sugar beets.
Sensitive Weeds: Annual nightshades, chickweed, knotweed, lady's-thumb, lamb's-quarters, oak-leaved goosefoot, prostrate pigweed, purslane, ragweed, redroot pigweed, shepherd's-purse, smartweed, stinkweed, wild buckwheat, wild carrot (seedling), wild mustard, wormseed mustard and yellow rocket (seedling).
Uptake and Translocation: Can be taken up by both roots and leaves, but translocation is upward to leaves where it inhibits photosynthesis.
Basis of Selectivity: Metabolism by tolerant species.
Application Methods: Preplant incorporated, preemergence, or postemergence after the second true-leaf stage of the beets.
Residual Activity: Average persistence is about 4–8 weeks in soil, depending on soil moisture and temperature. Residue carryover problems are unlikely.
Unique Characteristics: With preemergence applications, at least 1.25 cm of rainfall is required for good weed control. Combinations of pyrazon and TCA are most useful where both annual broadleaf weeds and grasses are a problem. These treatments may not be effective on high organic soils or dry soils (i.e., muck soils or with late planted beets when soils are drier). Under these circumstances, postemergence applications of pyrazon plus TCA as a band over the row may be most effective. However, to be selective and effective, the chemicals must be applied after the cotyledons of the beets are 2.5 cm long and before the weeds have reached the 4 true-leaf stage (10 cm). Where TCA has been used, beet tops should not be fed to livestock. TCA residues in the soil can be a problem for some crops such as corn.

PYRIDATE

Trade Name: LENTAGRAN.
Chemical Family: Phenyl pyridazine.
Crop and/or Non-Crop Registrations: Cabbage, sweet corn, tomato.
Sensitive Weeds: Annual broadleaf weeds (1- to 4-leaf stage) including triazine-resistant species, certain annual grasses (1- to 3-leaf stage) when weeds are actively growing. *Pyridate alone:* lamb's-quarters and redroot pigweed. *For Pyridate plus atrazine on corn and for pyridate plus metribuzin on tomatoes:* lamb's-quarters, redroot pigweed, nightshade, purslane, ragweed (common), wild mustard, velvetleaf and suppression of buckwheat (wild), lady's-thumb (smartweed), barnyard grass, crab grass (hairy), foxtail (green and yellow). Where heavy annual grass pressure is a problem, use a specific preemergence grass herbicide.
Uptake and Translocation: Rapidly absorbed by leaves and acts as a contact only.

Basis of Selectivity: It penetrates into both sensitive and tolerant plants but is quickly metabolized and inactivated in tolerant crops such as corn. In sensitive weeds, activity is evident by marginal yellowing, followed by yellowing and browning of the entire leaf. This visible evidence generally occurs within 4–7 days after application. Activity is more rapid at higher temperatures and under good growing conditions. Weed control under drought conditions may be decreased.
Application Method: Postemergence. Sprays can be applied overall on corn and directed on transplanted tomatoes.
Residual Activity: None.
Unique Characteristics: Combination with triazine herbicides improves total weed control. The stage of the weed, not the stage of the corn, determines application date. Tomatoes will show temporary yellowing, which is reduced by directing the spray to the bottom one-third of well-established tomato plants. Uptake by leaves is very rapid and rainfall shortly after application (1–2 hours) has little effect on the degree of control.

QUIZALOFOP-P-ETHYL

Trade Name: ASSURE II.
Chemical Family: Aryloxyphenoxypropionate.
Crop and/or Non-Crop Registrations: Sugar beets.
Sensitive Weeds: Green foxtail, barnyard grass, fall panicum, old witch grass, proso millet, wild oats, volunteer cereals and volunteer corn.
Uptake and Translocation: Rapidly absorbed and readily translocated in both the xylem and phloem from the treated foliage to the root system and growing points of the plant.
Basis of Selectivity: Disruption of fatty acid biosynthesis leading to increased permeability and cellular disruption in sensitive plants. Rapid metabolism of the active herbicide in tolerant species.
Application Methods: Postemergence.
Residual Activity: Rapid microbial degradation and essentially no soil activity.
Unique Characteristics: Apply with CANPLUS-411 at 5–10 litres per 1,000 litres of spray solution or SURE-MIX at 5 litres per 1,000 litres of spray solution. Tank-mix with PINNACLE or PINNACLE + BASAGRAN FORTE for control of broadleaf weeds.

RIMSULFURON

Trade Name: ELIM EP, PRISM.
Chemical Family: Sulfonylurea.
Crop and/or Non-Crop Registrations:
ELIM EP - Field corn. Not for use on sweet or seed corn.
PRISM - Potatoes, transplanted processing tomatoes. Not for use on potatoes grown for seed.
Sensitive Weeds: Green foxtail, fall panicum, barnyard grass, redroot pigweed (including triazine-resistant), hairy nightshade, suppression of yellow foxtail, witch grass, lamb's-quarters.
Uptake and Translocation: Following foliar application, rimsulfuron is rapidly absorbed through the leaves and translocated in both xylem and phloem.
Basis of Selectivity: Inhibition of acetolactate synthase (ALS) enzyme in susceptible plants leads to a rapid cessation of cell division and growth. Tolerant species rapidly convert rimsulfuron to non-phytotoxic metobolites.
Application Method: Postemergent, within the spike-to-3-leaf stage of corn. Prior to initiation of flowering in potatoes.
Residual Activity: Rapid soil microbial degradation.
Unique Characteristics: Emerged grasses will be controlled by rimsulfuron, but subsequent germinating grass weeds will not be controlled. A non-ionic surfactant must be added at 0.2% v/v. Typical symptoms of plant death (chlorosis, necrosis) occur 5–10 days after application, depending on growing conditions. Tank mix with dicamba for control of broadleaf weeds in corn. Do not apply rimsulfuron to corn that has been treated with an organophosphorous soil insecticide (i.e., COUNTER, LORSBAN, THIMET, CYGARD or DI-SYSTON). Do not use rimsulfuron on corn hybrids with a crop heat unit (CHU) rating of 2,500 or less, or in geographic regions with 2,500 or less average seasonal CHU. Rimsulfuron should not be sprayed for weed control in fields planted with some hybrids. SEE THE LABEL FOR LIST.

S-METOLACHLOR

Trade Names: DUAL MAGNUM, DUAL II MAGNUM.
Chemical Family: Acetanilide.
Crop and/or Non-Crop Registrations: Sweet corn, snap beans (yellow and green only), lima beans, transplanted cole crops (cabbage, cauliflower, broccoli), transplanted tomatoes, potatoes, sugar beets, processing peas, rutabagas.
Sensitive Weeds: Large and smooth crab grass; witch grass; barnyard grass; fall panicum; giant, green and yellow foxtail; yellow nut sedge; American nightshade, eastern black nightshade.
Uptake and Translocation: Absorbed by germinating grasses mainly through shoot just above seed. Absorbed by germinating broadleaf weeds through roots and shoots.
Basis of Selectivity: Metabolized by tolerant species.
Application Methods: Early preplant, preplant incorporated and preemergence. Early postemergence on corn (spike-to-2-leaf stage of corn). Incorporation equipment should be set to work the soil 10 cm deep with a disc operating at 6–10 km/hr or a vibrating shank cultivator

at 10–13 km/hr; one incorporation is sufficient and need not be immediate. Rainfall within 10 days is required for maximum activity of the preemergence application.
Residual Activity: Activity will normally be maintained for 10–14 weeks.
Unique Characteristics: The rate required depends on weed pressure (higher rate for heavier weed pressure). Yellow nut sedge control requires a preplant incorporated application. Winter cereals may be planted 4–5 months after metolachlor application. Many tank mix combinations are registered on various crops. Do not use on muck soils or coarse-textured soils low in organic matter. DUAL II MAGNUM contains benoxacor, a chemical that enhances the corn plant's ability to metabolize s-metolachlor, thereby preventing corn injury even under adverse environmental conditions.

S-METOLACHLOR/ATRAZINE

Trade Name: PRIMEXTRA II MAGNUM.
Chemical Family: Acetanilide/s-triazine.
Crop and/or Non-Crop Registrations: Sweet corn.
Sensitive Weeds: Germinating annual broadleaf weeds and annual grasses such as American nightshade, eastern black nightshade, lady's-thumb, lamb's-quarters, wild mustard, purslane, prostrate pigweed, redroot pigweed, wild buckwheat, smartweed, ragweed, crab grass, barnyard grass, green foxtail, yellow foxtail, giant foxtail, witch grass and fall panicum. Yellow nut sedge can be controlled with a preplant incorporated application.
Uptake and Translocation: Absorbed by germinating grasses mainly through shoot just above seed. Absorbed by germinating broadleaf weeds through roots and shoot.
Basis of Selectivity: Metabolized by tolerant species.
Application Methods: Early preplant, preplant incorporated and preemergence. Early postemergence on corn (spike-to-2-leaf stage of corn). Incorporation equipment should be set to work the soil 10 cm deep with a disc operating at 6–10 km/hr or a vibrating shank cultivator at 10–13 km/hr). One incorporation is sufficient and need not be immediate. Rainfall within 10 days is required for maximum activity of the preemergence application. S-metolachlor/atrazine may be applied in nitrogen solutions or liquid fertilizers for preplant incorporated or preemergence weed control. Dry bulk granular fertilizers may be impregnated with metolachlor/atrazine for preplant incorporation.
Residual Activity: Activity will normally be maintained for 10–14 weeks; late-germinating fall panicum will not be controlled. Soybeans, white beans, oats or barley may be planted the following spring.
Unique Characteristics: The rate required depends on weed pressure (higher rate for heavier weed pressure). Yellow nut sedge control requires a preplant incorporated application. Will not control triazine-resistant weed species. Contains atrazine in low amounts, which may carry over in a dry year. Is effective over a wide range of soil types and has a good margin of crop safety. Perennial weeds are not controlled. Primextra II MAGNUM contains benoxacor, a chemical that enhances the corn plant's ability to metabolize s-metolachlor, thereby preventing corn injury even under adverse environmental conditions.

SETHOXYDIM

Trade Name: POAST ULTRA.
Chemical Family: Cyclohexanedione.
Crop and/or Non-Crop Registrations: Snap beans, peas, onions, tomatoes, potatoes, sweet potato, pumpkin, squash, cucumbers, lima beans, garlic, broccoli, cabbage, cauliflower, peppermint, spearmint.
Sensitive Weeds: Annual grasses (wild oats, foxtails, barnyard grass, large crab grass, proso millet, fall panicum and witch grass), volunteer corn and cereals and quack grass.
Uptake and Translocation: Absorbed by foliage. Translocated upwards and downwards in plant.
Basis of Selectivity: Degraded by tolerant species (broadleaf plants).
Application Methods: Postemergence to actively growing annual grasses in the 1–6-leaf stage and quack grass in the 1–3-leaf stage. Use flat fan nozzles and add MERGE adjuvant to the spray mix. Alternatively, ASSIST OIL CONCENTRATE or ammonium sulphate plus ASSIST OIL CONCENTRATE may be used. Other postemergence herbicides that are not recommended as tank mix combinations on the label must be applied at least 4 days before or after sethoxydim application. Aerial application is also registered.
Residual Activity: Essentially none. A second application and/or cultivation may be necessary to control grasses that emerge after treatment.
Unique Characteristics: Susceptible grasses, when sprayed, stop growing immediately and then gradually turn yellow to purple to brown over a period of 7–21 days, depending on growing conditions and crop competition. Rainfall within 1 hour after application may reduce effectiveness. If treated grasses are stressed (drought, flooding, prolonged cool temperatures), control will be delayed or reduced.

SIDEKICK

Type of Adjuvant: Non-ionic liquid spreader/activator.
Chemical Composition: Alkylarylpolyoxyethylene glycols, free fatty acids & isopropyl alcohol
Registered Uses: For use with imazethapyr, metsulfuron-methyl, nicosulfuron, quinalofop-ethyl.
Benefit: Improves spray chemical effectiveness.

Mode of Action: It is a wetting and spreading agent that improves coverage of spray mixtures.
Mixing: Make sure the spray tank is thoroughly cleaned before mixing. Fill the spray tank half full with water. Add the required amount of herbicide as directed by its label with the agitator running. Ensure that the herbicide is completely mixed before proceeding to the next step. *slowly* add the SIDEKICK, agitating during the entire process. Continue to agitate while filling the tank with water and agitate before and during each application to insure a uniform spray.
Unique Characteristics: Do not exceed recommended rates of SIDEKICK, as too much may reduce the effectiveness of the herbicide due to excessive run-off. Consult product label for full directions.

SIMAZINE

Trade Names: PRINCEP NINE-T, SIMADEX, SIMAZINE, SIMAZINE 480.
Chemical Family: S-triazine.
Crop and/or Non-Crop Registrations: Corn, established asparagus.
Sensitive Weeds: Annual broadleaf weeds such as pigweed, lady's-thumb, lamb's-quarters, purslane, ragweed, volunteer clover, wild buckwheat, smartweed, plantain and groundsel; annual grasses such as barnyard grass, crab grass, wild oats and yellow foxtail (triazine-resistant biotypes of foxtail, lamb's-quarters, pigweed and groundsel will not be controlled); most perennial species starting freshly from seed.
Uptake and Translocation: Absorbed by roots; little or no foliar absorption; translocated upwards in xylem, accumulating in apical meristem and leaves with napropamide on new plantings of apples, apricot, cherries, plums, peaches and pears.
Basis of Selectivity: Some species, such as corn, metabolize simazine. In most crops, selectivity is based on the roots of the crop plants being deeper than the depth to which simazine leaches.
Application Methods: Preplant incorporated (to a depth of 2.5 cm) or preemergence in corn; preemergence in other crops. Broadcast or band application. In fruit crops, apply a 1-m wide band under the plants; cultivate or sod the area between the rows. For aquatic weed control, apply as a draw-down treatment or water-volume application in drainage ditches and ponds with no water flow-through.
Residual Activity: Soil residues may persist for more than 1 season. After spraying with simazine, do not plant any crop in the treated area in the same year except corn. Where rates in excess of 2 kg/ha have been applied, do not plant rotational crops in the following year; soils should be tested if there is any question of excessive residues remaining.
Unique Characteristics: Needs sufficient moisture to be activated. Should be applied only once per season. To avoid build-up of resistant weeds, simazine should be rotated with other non-triazine residual herbicides. Simazine is more persistant than atrazine. Where rainfall is sufficient to cause erosion, soil containing simazine may wash to lower areas of land and injure existing or subsequent crops.

SPRAY ADJUVANT DEFOAMER

Type of Adjuvant: Defoamer.
Chemical Composition: Dimethylpolysiloxane.
Registered Uses: To reduce foaming in spray mixes of atrazine.
Benefit: Reduces foaming.
Mixing: To control foam when mixing spray solution, add defoamer either just before or during addition of any other spray adjuvant. To cut existing foam, add defoamer to tank and recirculate solution until foam dissipates.
Unique Characteristics: Do not use with any other herbicide or herbicide/adjuvant mixture.

SUPER SPREADER STICKER

Type of Adjuvant: Non-ionic spreader sticker surfactant.
Chemical Composition: Octyl phenoxypoly ethoxy ethanol 50%.
Registered Uses: For use with ALLY, AMBER, atrazine, BASAGRAN, ethametsulfuron-methyl, thifensulfuron methyl, pyrazon, chlorsulfuron, thifensulfuron-methyl/trifenuron-methyl, nicosulfuron, rimsulfuron/nicosulfuron.
Benefit: Improves postemergence control of weeds that have reached their upper limit in size for susceptibility.
Mode of Action: Causes the spray mix to form a continuous film on leaf surfaces; also makes herbicide more rainfast.
Mixing: Half-fill tank with water; add herbicide with continuous agitation; complete filling of tank with water; add SUPER SPREADER STICKER with continuous agitation.
Unique Characteristics: Higher rates are required with hard water.

SURE-MIX

Type of Adjuvant: Paraffinic petroleum oil/surfactant (non-herbicidal).
Chemical Composition: 60% Paraffinic petroleum oil plus 35.6% surfactant blend.
Registered Uses: SURE-MIX is registered for use with ASSURE II.

Benefit: The use of SURE-MIX results in improved activity of ASSURE II and a greater degree of consistency under varying environmental conditions.
Mode of Action: Reduces the evaporation of spray droplets from the leaf surface and decreases the surface tension of spray droplets, thus improving penetration through the cuticle of leaf surfaces.
Mixing: Add the required amount of water to the spray tank with agitator running. Add ASSURE II and after well mixed add 5 litres of SURE-MIX for each 1,000 L of spray solution.
Unique Characteristics: May cause some minor leaf speckling under hot and humid weather conditions.

SURFACTANTS

(See AGRAL 90, AG-SURF, CANPLUS 411, CITOWETT PLUS, ENHANCE, LI700, MERGE, SIDEKICK).

TERBACIL

Trade Name: SINBAR.
Chemical Family: Uracil.
Crop and/or Non-Crop Registrations: Asparagus, spearmint, peppermint.
Sensitive Weeds: Barnyard grass, bluegrass, crab grass, foxtail, chickweed, cheat grass, perennial rye grass, wild barley, mustard, prickly lettuce, stinkweed, annual sowthistle, henbit, lamb's-quarters, pigweed, purslane and ragweed. Partial control of quack grass, horsenettle, vetch and yellow nut sedge.
Uptake and Translocation: Uptake is mostly through roots, although partially through foliage and stem. Translocation is upward into leaves.
Basis of Selectivity: Used only on established plantings so that roots of crop are below depth to which chemical penetrates. May also be slower translocation and faster degradation in tolerant species.
Application Methods: Apply to the soil surface in 200–1,000 L water/ha. If weed growth is present in apples, paraquat may be mixed with spray. Rates for strawberries are considerably lower and can be applied in spring, postharvest or late fall. Control of perennial grasses may be improved by cultivation prior to treatment.
Residual Activity: May be up to 2 years. Residues are likely to be higher on heavier soil types if higher rates and repeated applications are used.
Unique Characteristics: Moisture is necessary to activate the chemical within 2 weeks after application. Do not apply on soils with less than 1% organic matter, nor on eroded soil areas. Use lower rates on soils with 1–2% organic matter. Do not apply on weak or diseased strawberry plants.

TRIALLATE

Trade Name: AVADEX BW
Chemical Family: Thiocarbamate.
Crop and/or Non-Crop Registrations: Sugar beets.
Sensitive Weeds: Wild oats.
Uptake and Translocation: Absorbed mainly by the coleoptile of wild oats.
Application Methods: Postplant incorporated (spring wheat and barley). Preplant incorporated (barley, flax, rapeseed, sugar beets, mustard and dry peas). For postplant treatment of the cereals, the spray is applied to the soil after the crop is seeded and then thoroughly worked into the soil by harrowing twice, the second harrowing at right angles to the first; the crop should be seeded uniformly, deep enough so it is not disturbed by the harrow. For preplanting treatments, the chemical is sprayed on the soil surface and worked into the top 5–8 cm of soil with a disk or cultivator implement. The crop can be seeded anytime after treatment. In all treatments, the chemical should be worked into the soil within 2 hours after spraying.
Residual Activity: Half-life in soil of approximately 6–8 weeks.

TRIFLURALIN

Trade Names: BONANZA 400, RIVAL, TREFLAN.
Chemical Family: Dinitroaniline.
Crop and/or Non-Crop Registrations: Snap beans, lima beans, turnips, peas (field and canning), transplants of tomatoes, peppers, Brussels sprouts, broccoli, cabbage and cauliflower; carrots, direct-seeded cabbage and cauliflower.
Sensitive Weeds: Effective on most annual grasses, and will provide good control of pigweed and lamb's-quarters, including the triazine-tolerant biotypes of these weeds.
Uptake and Translocation: No significant absorption or translocation of trifluralin in crops grown in soil treated with trifluralin. Susceptible weeds are controlled as they germinate. Established weeds are not controlled.
Basis of Selectivity: Physiological growth processes associated with seed germination.
Application Methods: Preplant incorporated. Apply in 100–300 L of water/ha. Use lower rate of the chemical on sandy soils and increased rate for loam-to-clay soils. Do not use on highly organic soils (muck, peat or black sands above 15% organic matter). Incorporate twice in cross directions using a tandem disc (7–10 km/hr) or tine cultivator (10–13 km/hr) set to work 8–10 cm deep. The first incorporation should be done as soon as possible after application, but may be delayed 8–24 hours, depending on label directions. The second incorporation is recommended anytime before planting. Activated upon incorporation; rainfall is not required.

Residual Activity: Recommended application rates provide season-long weed control. Succeeding crops, even fall-seeded grain crops planted in soil that received trifluralin the preceding spring, will not be injured under normal conditions.

Unique Characteristics: Strongly adsorbed to soil particles and shows negligible leaching. Organic matter and clay content influence application rate. Does not control ragweed, annual nightshades or mustards; lady's-thumb may escape.

TRIFLUSULFURON-METHYL

Trade Name: UPBEET.

Chemical Family: Sulfonylurea.

Crop and/or Non Crop Registrations: Sugar beets. With BETAMIX on sugar beets.

Sensitive Weeds: Redroot and green pigweed, velvetleaf.

Uptake and Translocation: Following foliar application, the herbicide is rapidly absorbed and translocated in both the xylem and phloem to growing points of sensitive weeds.

Basis of Selectivity: Inhibition of acetolactase synthase (ALS) enzyme in susceptible plants that leads to a rapid cessation of cell division and plant growth. Tolerant species rapidly metabolize the herbicide into non-phytotoxic metabolites.

Application Methods: Postemergence.

Residual Activity: None.

Unique Characteristics: Must be applied with an approved adjuvant system including 0.2% v/v non-ionic surfactant. Addition of 28% urea ammonium nitrate (U.A.N.) at 2 L/ha will improve weed control. Plant death of target weeds may take from 1–3 weeks for visual symptoms to develop. Symptoms develop more quickly under favourable growing conditions.

WATER-SOLUBLE DYES

See AQUASHADE.

XA OIL CONCENTRATE

Type of Adjuvant: Mineral oil/surfactant (non-herbicidal).

Chemical Composition: Paraffin-base mineral oil 83%, surfactant blend 17%.

Registered Uses: As a tank mix with atrazine, quizalofop-ethyl, BASAGRAN or bentazon/atrazine. Follow all product labels involved. Care should be taken when applying XA OIL CONCENTRATE on new corn varieties, especially those not treated previously with oil concentrate. Oil concentrates may cause crop injury when applied to a crop that is in a stress condition from extreme weather conditions such as cold weather or hot dry weather and drought. The risk of damage to other vegetation from spray drift is increased with the use of atrazine in oil-water emulsion. Do not add 2,4-D, MCPA, 2,4-DB, cyanazine, MCPB or dicamba or any other herbicide to a mixture of XA OIL CONCENTRATE and atrazine. Do not reduce the rates recommended on the atrazine label.

Benefit: Improved postemergence activity of herbicides.

Mode of Action: Partially dissolves waxy cuticle of weeds allowing herbicides to penetrate more readily. Reduces evaporation and aids in spreading of spray droplets on the leaf surface leading to a longer period of penetration.

Mixing: Avoid violent agitation; partially fill sprayer, add the herbicide, add XA OIL CONCENTRATE last.

Tank mix with ATRAZINE: Use 2.75–5.50 L/ha of XA OIL CONCENTRATE plus the recommended amount of atrazine liquid, wettable powder or dry flowable in 200–300 L of water/ha. This is at the rate of 1.25 L XA OIL CONCENTRATE/100 L of water.

Tank mix with quizalofop-ethyl: Use 5–10 L of XA OIL CONCENTRATE/1000 L of spray solution.

Tank mix with BASAGRAN:

Ground Application: 100–400 L/ha. Use 1 L of XA OIL CONCENTRATE/100 L of spray volume to a maximum rate of 2 L/ha. Restrict application rate to 1 L/ha under hot, humid conditions.

Aerial Application: 50–100 L/ha. Use 0.125–0.25 L of XA OIL CONCENTRATE/ha. Do not use XA OIL CONCENTRATE in excess of 0.25 L/ha as substantial crop injury could occur.

Tank mix with bentazon/atrazine: Use 10 L of XA OIL CONCENTRATE/1,000 L of spray solution.

Unique Characteristics: Some injury may occur with cold, rainy weather when mixed with atrazine on corn.

Pesticides Listed by Trade Name

Table 6–2, *Pesticides Used on Vegetable Crops in Ontario,* which starts on page 167, lists pesticides alphabetically by brand or trade name. The legend for the company or agent's codes listed in the last column follows the table (see page 178).

TABLE 6–2.
Pesticides Used on Vegetable Crops in Ontario

Formulation Code:
D = dust
DC = dispersible concentrate
DF = dry flowable
DG = dry granules
EC = emulsifiable concentrate
EW = water-based concentrate
Fl = flowable
Gl = gel
Gr = granular
Li = liquid
SC = soluble concentrate
SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

Examples of Brand Name/ Trade Name[a]	Active Ingredient/ Common Name	Formulation	Guaranteed % Active Unless Stated	Crop Recommended Registrations	Target Pests	Company or Agent's code[b]
2,4-D	2,4-D	Sn	470 g/L	asparagus	broadleaf, perennial weeds	****
AATREX	atrazine	Su	480 g/L	sweet corn	broadleaf weeds	NOV
AATREX NINE-O	atrazine	WG	90	sweet corn	broadleaf weeds	NOV
ACCENT	nicosulfuron	DF	75	certain varieties of sweet corn	grasses	DUQ
acephate	*See ORTHENE*					
ACROBAT	dimethomorph/ mancozeb	EC	9,60	potato	early & late blight	ENG
ADMIRE	imidacloprid	Fl	240 g/L	potato, tomato, lettuce	Colorado potato beetle, aphids	BBB
AFESIN	monolinuron	EC	200 g/L	potato, bean (kidney, lima, snap)	broadleaf weeds & some annual grasses	ARV
AFOLAN F	linuron	Su	480 g/L	asparagus, carrot, celery, dill, parsnip, potato, sweet corn	annual weeds	ARV
AGRICULTURAL WEED KILLER #1	mineral oil (herbicidal)	Li	100	carrot, celery, dill, parsley, parsnip	annual weeds	VAR
ALANAP-3	naptalam	Sn	240 g/L	cucumber, melon, squash, pumpkin	some annual seedlings, crabgrass & foxtail	UNR
ALIETTE	fosetyl-al	WG	80	lettuce, onion	onion downy mildew & purple blotch; lettuce downy mildew	RHQ
AMITROL-T	amitrole	Sn	200 g/L	pea	annual and perennial broadleaf weeds, grasses	NUA
APM	azinphos methyl	WP	50	cabbage, cauliflower, broccoli, Brussels sprout, bean, cucumber, melon, pumpkin, squash, sugar beet, tomato	various insects (check label and/or specific crop section)	NOR
ASSURE II	quizalofop-p-ethyl	EC	96 g/L	sugar beet	annual grasses, volunteer cereals	DUQ
atrazine	*See AATREX, AATREX NINE-0, ATRAZINE*					
ATRAZINE 480	atrazine	Su	480 g/L	sweet corn	broadleaf weeds	UAG
ATRAZINE 80W	atrazine	WP	80	sweet corn	broadleaf weeds	****
ATRAZINE 90W	atrazine	WG	90	sweet corn	broadleaf weeds	****
ATRAZINE 500	atrazine	Su	500 g/L	sweet corn	broadleaf weeds	CPM
AVADEX BW	triallate	EC	400 g/L	sugar beet	wild oats	MOL
azinphos-methyl	*See APM, GUTHION, SNIPER*					
Bacillus thuringiensis	*See DIPEL, NOVODOR, THURICIDE*					
BASAGRAN	bentazon	Sn	480 g/L	peas, lima & snap bean, sweet corn	annual broadleaf weeds	BAZ
BASAMID	dazomet	Gr	98	eggplant, lettuce, pepper, tomato seedbeds	germinating weed seeds	BAZ
BELMARK	fenvalerate	EC	300 g/L	cabbage, cauliflower, Brussels sprout	various insects (check label and/or specific crop section)	DUQ
BENLATE	benomyl	WP	50	bean, carrot, cucumber, tomato	white mould, scab, *Septoria* leaf spot	DUQ
benomyl	*See BENLATE*					
bensulide	*See PREFAR*					
bentazon	*See BASAGRAN*					
bentazon/atrazine	*See LADDOCK*					
BETAMIX	desmedipham/ phenmedipham	EC	(1:1) 150 g/L	sugar beet	foxtail; some broadleaf weeds	ARV
BETANEX	desmedipham	EC	150 g/L	sugar beet	some broadleaf weeds	ARV

TABLE 6–2.
Pesticides Used on Vegetable Crops in Ontario (Continued)

Formulation Code:
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DC = dispersible concentrate
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Fl = flowable
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Gr = granular
Li = liquid
SC = soluble concentrate
SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

Examples of Brand Name/ Trade Name[a]	Active Ingredient/ Common Name	Formulation	Guaranteed % Active Unless Stated	Crop Recommended Registrations	Target Pests	Company or Agent's code[b]
BLADEX 90 DF	cyanazine	DF	90	sweet corn	grasses; annual broadleaf weeds	DUQ
BLADEX LIQUID	cyanazine	Li	480 g/L	sweet corn	as above	DUQ
BONANZA 400	trifluralin	EC	400 g/L	snap/lima bean, Brussels sprout, cabbage, cauliflower, carrot, pea, pepper, transplant tomato, turnip	annual grasses, pigweed, lamb's quarters	UAG
BOTRAN	dichloran	WP	75	garlic, lettuce, bean	white rot, white mould	UAG
BRAVO	chlorothalonil	Fl	500 g/L	cabbage, cauliflower, broccoli, Brussels sprout	downy mildew	ZNA
				carrot, celery	leaf blight	
				cucumber, melon, pumpkin, squash	scab (cucumber), anthracnose, powdery mildew	
				onion	leaf blight, downy mildew, purple blotch	
				parsnip	*Phoma* canker, leaf spot	
				potato	early, late blight	
				sweet corn	rust	
				tomato	leaf spot, early, late blight	
bromoxynil	*See PARDNER*					
BUSAN	metam sodium	Sn	33	vegetables (non-crop area)	weeds, some diseases	BUL
captan	*See CAPTAN, MAESTRO*					
CAPTAN	captan	WP	50 or 80	eggplant, pepper transplants	damping-off	TMO
		W	80	cucumber	anthracnose, scab	UAG
				tomato	anthracnose, *Septoria* spot	
		WDG	80	cucumber	anthracnose, scab	UAG
				tomato	anthracnose, *Septoria* spot, early & late blight	
carbaryl	*See SEVIN XLR*					
carbathiin-thiram	*See PRO-GRO*					
carbofuran	*See FURADAN*					
CHAMPION	copper hydroxide	WP	50	bean	bacterial blight	VAR
				cucumber	angular leaf spot	
				pepper, tomato	bacterial leaf spot	
				potato	early and late blight	
chlorothalonil	*See BRAVO*					
chlorpyrifos	*See LORSBAN, PYRIFOS, PYRINEX*					
CIPC	chlorpropham	Gr	20	carrot, lettuce, onion, spinach	annual grasses, broadleaf weeds	STD
CIPC EC	chlorpropham	EC	480 g/L	potato	sprout inhibitor	
clethodim	*See SELECT*					
clopyralid	*See LONTREL*					
COPPER 53	copper sulfate	WP	53	beet	leaf spot	UAG
				cabbage, cauliflower, broccoli, Brussels sprout	downy mildew	
				celery	leaf blights	
				cucumber	angular leaf spot	
				potato	late blight	
copper hydroxide	*See CHAMPION, KOCIDE 101, DF*					
copper oxychloride	*See COPPER SPRAY*					

TABLE 6–2.
Pesticides Used on Vegetable Crops in Ontario (Continued)

Formulation Code:
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DC = dispersible concentrate
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EW = water-based concentrate
Fl = flowable
Gl = gel
Gr = granular
Li = liquid
SC = soluble concentrate
SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

Examples of Brand Name/ Trade Name[a]	Active Ingredient/ Common Name	Formulation	Guaranteed % Active Unless Stated	Crop Recommended Registrations	Target Pests	Company or Agent's code[b]
copper sulphate	*See COPPER 53*					
copper ethanolamine	*See CUTRINE PLUS*					
COPPER SPRAY	copper oxychloride	WP	50	celery	leaf blights	UAG
				potato	late blight	
COUNTER	terbufos	Gr	15	rutabaga	cabbage maggot	CYC
				sugar beet	wireworm	
CURZATE	cymoxanil	DF	60	potato	late blight	DUQ
CUTRINE PLUS	copper ethanolamine	Sn	9	for use in ponds	pond weeds	APB
cyanazine	*See BLADEX*					
cycloate	*See RO-NEET*					
cyhalothrin-lambda	*See MATADOR*					
cymoxanil	*See CURZATE*					
cypermethrin	*See CYMBUSH, RIPCORD*					
cyromazine	*See GOVERNOR*					
CYGON	dimethoate	EC	480 g/L	asparagus, bean, beet, cabbage, cauliflower, broccoli, Brussels sprout, kale, eggplant, lettuce, pea, pepper, potato, rutabaga, Chinese broccoli, Chinese cabbage, pak choy, spinach, swiss chard, tomato	various insects (check label and/or various crop sections)	CYC
CYMBUSH	cypermethrin	EC	250 g/L	asparagus, broccoli, cabbage, cauliflower, Brussels sprout, kale, carrot, celery, lettuce, onion, potato, rutabaga, sweet corn, tomato	various insects (check label and/or various crop sections)	ZNA
dazomet	*See BASAMID*					
DECIS	deltamethrin	EC	50 g/L	asparagus, broccoli, Brussels sprout, cabbage, cauliflower, kale, onion, pepper, potato, sweet corn	various insects (check label and/or various crop sections)	ROH
deltamethrin	*See DECIS*					
DES-I-CATE	endothall	Li	62 g/L	potato	vine killing	EFA
desmedipham	*See BETANEX*					
desmedipham/ phenmedipham	*See BETAMIX*					
DEVRINOL 50W	napropamide	WP	50	asparagus, broccoli, basil, cabbage, cauliflower, Chinese broccoli, Chinese cabbage, Asian radish, kohlrabi, garlic, pepper, pumpkin, squash, rutabaga, tomato	annual grasses, broadleaf weeds	UAG
DEVRINOL DF		DF				
DIAZINON	diazinon See DZN also.	WP	50	beet, carrot, lettuce, onion, parsnip, pepper, radish, spinach, tomato	various insects (check label and/or various crop sections)	UAG
		EC	500 g/L			
DIBROM	naled	EC	864 g/L	broccoli, Brussels sprout, cabbage, cauliflower, kale, mustard green, lima bean, celery, lettuce, endive, onion, pea, potato, spinach, sugarbeet, swiss chard, tomato	various insects (check label and/or various crop sections)	UAG
dichloran	*See BOTRAN*					
dichlorpropene/ chloropicrin	*See TELONE C17R*					
diclofop-methyl	*See HOE-GRASS-284*					

TABLE 6–2.
Pesticides Used on Vegetable Crops in Ontario (Continued)

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SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

Examples of Brand Name/ Trade Name[a]	Active Ingredient/ Common Name	Formulation	Guaranteed % Active Unless Stated	Crop Recommended Registrations	Target Pests	Company or Agent's code[b]
dicofol	*See KELTHANE*					
dimethenamid	*See FRONTIER*					
dimethoate	*See CYGON, LAGON*					
dimethomorph/ mancozeb	*See ACROBAT*					
DIPEL 2X	Bacillus thuringensis	DF	32,000/mg	broccoli, Brussels sprouts, cabbage, cauliflower, kale, lettuce, parsley, rutabaga, spinach, Chinese broccoli, Chinese cabbage, Asian radish, bok choy, mustard greens	cabbageworm, diamondback moth, cabbage looper, hornworm	ABT
diquat	*See REGLONE*					
disulfoton	*See DI-SYSTON*					
DI-SYSTON	disulfoton	Gr	15	lettuce	aster leafhopper	BBB
				potato	Colorado potato beetle	
DITHANE M45, DG	mancozeb	DG	80,75	carrot, celery	leaf blights	ROH
				cucumber, melon, squash, pumpkin	scab (cucumber), anthracnose	
				dry onion	downy mildew, leaf blight, purple blotch, smut (DG)	
				potato	early, late blight	
				tomato	early, late blight, anthracnose	
				sugar beet (not DG)	*Cercospora* leaf spot	
diuron	*See KARMEX*					
DUAL MAGNUM	s-metolachlor	EC	915 g/L	potato, transplanted tomato, rutabaga, transplanted cabbage, cauliflower, broccoli, yellow and green snap bean, lima bean, processing pea, sugar beet	annual grasses, nightshade, pigweed	NOV
DUAL II MAGNUM	s-metolachlor/ benoxacor	EC	915 g/L	sweet corn	as above	NOV
DZN	diazinon	EW	600 g/L	beet, carrot, lettuce, onion, parsley, parsnip, pepper, radish, spinach, swiss chard, tomato	various insects (check label and/or various crop sections)	NOV
EDGE	ethalfluralin	DC	60	transplanted pepper	annual grasses, broadleaf weeds	DWE
ENDOSULFAN	endosulfan	WP	50	bean, broccoli, Brussels sprouts, cabbage, cauliflower, celery, cucumber, melon, pumpkin, squash, eggplant, head lettuce, pepper, potato, rutabaga, spinach, sugar beet, tomato	various insects (check label and/or various crop sections)	UAG
ENDOSULFAN 400	See THIODAN, THIONEX also	EC	400 g/L			
endothall	*See DES-I-CATE*					
EPTAM	EPTC	EC	800 g/L	snap bean, potato	annual grasses, nutsedge & some broadleaf weeds	ZNA
ERADICANE	EPTC/R25788	EC	800 g/L	sweet corn	as above	ZNA
ESTASOL	2,4-D	EC	564 g/L	asparagus, non-crop land	broadleaf weeds	RHQ
ESTEMINE 2,4-D		Sn	470 g/L			UAG
ethalfluralin	*See EDGE*					
ETHION 5/ THIRAM G	ethion/thiram	Gr	5/7.5	onion	onion maggot	VAR
ethofumesate	*See NORTRON SC*					

TABLE 6–2.
Pesticides Used on Vegetable Crops in Ontario (Continued)

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Fl = flowable
Gl = gel
Gr = granular
Li = liquid
SC = soluble concentrate
SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

Examples of Brand Name/ Trade Name[a]	Active Ingredient/ Common Name	Formulation	Guaranteed % Active Unless Stated	Crop Recommended Registrations	Target Pests	Company or Agent's code[b]
EXCEL SUPER	fenoxaprop-p-ethyl	EC	80.5 g/L	asparagus, broccoli, cabbage, cauliflower, carrot, dry onion, pea, potato, tomato	annual grasses	ARV
fenoxaprop-p-ethyl	*See EXCEL*					
fenvalerate	*See BELMARK*					
FERBAM	ferbam	WG	76	transplant lettuce	*Botrytis*	UAG
fluazifop-p-butyl	*See FUSILADE II*					
fomesafen	*See REFLEX*					
fosetyl-al	*See ALIETTE*					
FRONTIER	dimethenamid	EC	900 g/L	sweet corn	annual grasses, pigweed, nightshade	BAZ
FURADAN	carbofuran	Fl	480 g/L	pepper	corn borer	BBB
				sweet corn	rootworm, corn borer	
FUSILADE II	fluazifop-p-butyl	EC	125 g/L	broccoli, Brussels sprouts, cabbage, cauliflower, cucumber, onion, potato, rutabaga, tomato	annual grasses, quackgrass, volunteer corn, wheat, barley	ZNA
GESAGARD 480	prometryne	Su	480 g/L	carrot, celery, leek, pea	foxtail, annual weeds	NOV
glufosinate ammonium	*See IGNITE*					
GLYFOS	glyphosate	Su	360 g/L	same as Renegade, etc.	same as Renegade, etc.	CAU
glyphosate	*See GLYFOS, LAREDO, RENEGADE, ROUNDUP, TOUCHDOWN, WRANGLER*					
glyphosate/ glufosinate ammonium	*See ROUNDUP FASTFORWARD PRESEED*					
GOAL 2XL	oxyfluorfen	EC	240 g/L	onion	some annual weeds	ROH
GOVERNOR	cyromazine	WP	75	onion seed treatment	onion maggot	NOV
GRAMOXONE	paraquat	Sn	200 g/L	stale seedbed, inter-row weeding	green plants	ZNA
GUTHION	azinphos methyl	WP	50	bean, broccoli, Brussels sprout, cabbage, cauliflower, cucumber, potato, tomato	various insects (check label and/or various crop sections)	BBB
GUTHION 240		SC	240 g/L			
HOE-GRASS-284	diclofop-methyl	EC	284 g/L	snap, lima bean, carrot, onion, pea, potato	annual grasses	ARV
IGNITE	glufosinate ammonium	Sn	150 g/L	potato	vine killing	ARV
				asparagus, carrot, lettuce, onion	stale seedbed technique	
imidacloprid	*See ADMIRE*					
imazethapyr	*See PURSUIT*					
IMIDAN	phosmet	WP	50	carrot, celery	carrot weevil	UAG
iprodione	*See ROVRAL*					
KARMEX	diuron	DF	80	asparagus	grasses, some broadleaf weeds	GRN
KELTHANE	dicofol	WP	50	bean, cucumber, melon, pumpkin, squash	spider mites	ROH
KERB	propyzamide	WP	50	lettuce	annual grasses, volunteer cereals, chickweed	ROH
KOCIDE 101	copper hydroxide	WP	77	bean	bacterial blight	UAG
				cucumber	angular leaf spot	
				pepper, tomato	bacterial leaf spot	
				potato	early, late blight	
				sugar beet	*Cercospora* leaf blight	

TABLE 6–2.
Pesticides Used on Vegetable Crops in Ontario (Continued)

Formulation Code:
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SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

Examples of Brand Name/ Trade Name[a]	Active Ingredient/ Common Name	Formulation	Guaranteed % Active Unless Stated	Crop Recommended Registrations	Target Pests	Company or Agent's code[b]
KOCIDE DF	copper hydroxide	DF	61.4	pepper	bacterial leaf spot	UAG
				potato	early, late blight	
LADDOK	bentazon/atrazine	Su	(1:1) 400	sweet corn	broadleaf weeds	BAZ
LAGON	dimethoate	EC	480 g/L	asparagus, bean, cabbage, cauliflower, broccoli, Brussels sprout, kale, lettuce, pea, pepper, potato, spinach, swiss chard, tomato	various insects (check label and/or various crop sections)	UAG
LANNATE L	methomyl	SP	90	bean, broccoli, Brussels sprouts, cabbage, cauliflower, head lettuce, pea, sweet corn, tomato	various insects (check label and/or various crop sections)	DUQ
LAREDO	glyphosate	Sn	356 g/L	pre-plant/postharvest all crops	annual grasses, perennial weeds	MOL
LENTAGRAN	pyridate	WP	45	cabbage, sweet corn, tomato	annual grasses & some broadleaf weeds	NOV
LEXONE DF	metribuzin	DF	75	asparagus, potato, transplant tomato	grasses & broadleaf weeds	DUQ
LINDANE	lindane	WP	25,50	see seed treatment section, page 11		****
LINURON 480	linuron See AFOLAN, LOROX also	Su	480 g/L	asparagus, carrot, celery, dill, parsnip, potato, sweet corn	annual grasses & broadleaf weeds	UAG
LONTREL	clopyralid	Sn	200 g/L	broccoli, cabbage, cauliflower, nappa cabbage, Asian radish, Chinese broccoli, mustard cabbage, rutabaga	some annual & perennial broadleaf weeds	DWE
LONTREL 360			360 g/L			
LOROX DF	linuron	DF	50	asparagus, carrot, celery, dill, parsnip, potato, sweet corn	annual grasses & broadleaf weeds	GRN
LOROX L		Su	480 g/L			
LORSBAN	chlorpyrifos	Gr	15	onion	onion maggot	DWE
				broccoli, Brussels sprout, cabbage, cauliflower, rutabaga	cabbage maggot	
LORSBAN 4E	chlorpyrifos	EC	480 g/L	broccoli, Brussels sprout, bulb onion, cabbage, carrot, cauliflower, celery, Chinese cabbage, Chinese broccoli, cucumber, garlic, pak choy, radish, Asian radish, pepper, potato, rutabaga, sugar beet, sweet corn, tomato	cutworm and various insects; (check label and/or various crop sections)	DWE
LORSBAN 50W	chlorpyrifos	WP	50	cabbage	cabbage maggot	DWE
MAESTRO	captan	DF	75	cucumber	anthracnose, scab	TMO
				tomato	anthracnose, *Septoria* leaf spot	
MALATHION	malathion	WP	25	asparagus, bean, beet, cucumber, melon, pumpkin, squash, pea, pepper, spinach, tomato	various insects (check label and/or various crop sections)	****
MALATHION 500	malathion	EC	500 g/L	asparagus, bean, beet, celery, cucumber, garlic, melon, pumpkin, radish, squash, pea, tomato	various insects (check label and/or various crop sections)	****
maleic hydrazide	*See ROYAL MH 60*					
mancozeb	*See DITHANE, TUBERSEAL, POTATO ST, PENNCOZEB*					
MANZATE DF	mancozeb	DF	75	carrot, celery, onion	leaf blight	GRN
				cucumber	scab, anthracnose	
				potato	early & late blight	
				tomato	bacterial leaf spot, leaf blight, *Septoria*, anthracnose	
				sugar beet	*Cercospora* leaf spot	

TABLE 6–2.
Pesticides Used on Vegetable Crops in Ontario (Continued)

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Fl = flowable
Gl = gel
Gr = granular
Li = liquid
SC = soluble concentrate
SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

Examples of Brand Name/ Trade Name[a]	Active Ingredient/ Common Name	Formulation	Guaranteed % Active Unless Stated	Crop Recommended Registrations	Target Pests	Company or Agent's code[b]
MATADOR	cyhalothrin-lambda	EC	120 g/L	broccoli, Brussels sprout, cabbage, cauliflower, garlic, head lettuce, onion, potato, sweet corn, tomato	various insects (check label and/or various crop sections)	ZNA
MCPB/MCPA	*See TROPOTOX PLUS*					
metalaxyl	*See RIDOMIL*					
metalaxyl/ chlorothalonil	*See RIDOMIL/BRAVO*					
metam sodium	*See BUSAN, VAPAM*					
methamidophos	*See MONITOR*					
methomyl	*See LANNATE*					
METHOXYCHLOR	methoxychlor	WP	50	asparagus	asparagus beetle	UAG
				cucumber, melon, squash	cucumber beetle	
methyl bromide/ chloropicrin	*See TERR-O-GAS 67*					
methyl isothiocyanate/ dichloropropene/ chloropicrin	*See VORLEX PLUS CP*					
metiram	*See POLYRAM*					
metobromuron	*See PATORAN FL*					
metribuzin	*See SENCOR, LEXONE*					
MICRO NIASUL	sulphur	WP	92	rutabaga	powdery mildew	WBR
MICROSCOPIC SULPHUR	sulphur	WP	92	rutabaga	as above	UAG
mineral oil	*See AGRICULTURAL WEED KILLER, SUPERIOR OIL 70*					
MONITOR	methamidophos	EC	480 g/L	broccoli, Brussels sprout, cabbage, cauliflower, head lettuce	various insects (check label and/or specific crop section)	BBB
monolinuron	*See AFESIN*					
myclobutanil	*See NOVA*					
naled	*See DIBROM*					
napropamide	*See DEVRINOL*					
naptalam	*See ALANAP-3*					
nicosulfuron	*See ACCENT*					
NO-DAMP	oxine benzoate	Li	2.5	vegetable seedlings	damping-off disease	PLG
NORTRON SC	ethofumesate	SC	480 g/L	sugar beets	some broadleaf weeds and grasses	ARV
NOVA	myclobutanil	WP	40	asparagus	rust	ROH
NOVODOR	*Bacillus thuringensis*	Fl	15,000/g	potato	Colorado potato beetle	NID
ORTHENE	acephate	Sp	75	broccoli, Brussels sprout, cabbage, cauliflower, celery, head lettuce, pepper, potato, sweet corn, tomato	various insects (check label and/or various crop sections)	UAG
oxamyl	*See VYDATE*					
oxine benzoate	*See NO-DAMP*					
oxyfluorfen	*See GOAL 2XL*					
paraquat	*See GRAMOXONE*					
PARATHION	parathion	EC	960 g/L	beet, broccoli, Brussels sprout, cabbage, carrot, cauliflower, celery, kale, lettuce, onion, pea, spinach	Various insects (check label and/or various crop sections)	UAG

TABLE 6–2.
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Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

Examples of Brand Name/ Trade Name[a]	Active Ingredient/ Common Name	Formulation	Guaranteed % Active Unless Stated	Crop Recommended Registrations	Target Pests	Company or Agent's code[b]
PARDNER	bromoxynil	EC	280 g/L	garlic, sweet corn	wild buckwheat, smartweed, lamb's quarters, wild mustard	RHQ
PARDNER GEL		Gl	480 g/L			
PATORAN FL	metobromuron	Su	400 g/L	lima, snap, adzuki bean, potato	annual grasses & broadleaf weeds	NOV
pendimethalin	*See PROWL*					
PENNCOZEB	mancozeb	DF	75	carrot, celery	leaf blights	UAG
				cucumber, melon, pumpkin,	scab (cucumbers only)	
				squash	anthracnose	
				onion	downy mildew, leaf blight	
				potato	early & late blight	
				tomato	anthracnose & leaf blight	
permethrin	*See POUNCE*					
phenmedipham	*See SPIN-AID*					
phorate	*See THIMET*					
phosmet	*See IMIDAN*					
PIRIMOR	pirimicarb	DF	50	asparagus, lettuce, pea, pepper, potato	aphids	ZNA
POAST ULTRA	sethoxydim	EC	450 g/L	snap, lima bean, pea, onion, tomato, potato, cucumber, broccoli, cabbage, cauliflower, Chinese broccoli, Asian radish, kohlrabi, Nappa cabbage, mustard cabbage, garlic, sweet potato, peppermint, spearmint	annual grasses, volunteer corn and cereals, quackgrass	BAZ
POLYRAM	metiram	DF	80	asparagus	rust	BAZ
				carrot, celery	leaf blights	
				potato	early & late blight	
				tomato	early blight, *Septoria* leaf spot, anthracnose	
				sugar beet	*Cercospora* leaf spot	
POTATO ST 16	mancozeb	D	16	potato seed piece	*Fusarium*	UAG
POUNCE	permethrin	EC	384 g/L	asparagus, bean, broccoli, Brussels sprouts, cabbage, cauliflower, Chinese broccoli, Chinese cabbage, Asian radish, bok choy, pak choy, horseradish, mustard greens, pepper, potato, radish, rutabaga, sugar beet, sweet corn, tomato	various insects (check label and/or specific crop section)	UAG
PREFAR	bensulide	EC	480 g/L	cucumber	annual grasses	UAG
PRIMEXTRA II MAGNUM	s-metolachlor/ benoxacor/ atrazine	SC	(1:0.8) 720 g/L	sweet corn	annual broadleaf weeds & grasses	NOV
PRINCEP NINE-T	simazine	WG	90	sweet corn, asparagus	annual broadleaf weeds & grasses	NOV
PRISM	rimsulfuron	DF	25	potato, transplanted processing tomato	foxtail, fall panicum, barnyard grass, pigweed, hairy nightshade, lamb's-quarters, witch grass	DUQ
PRO-GRO	carbathiin-thiram	D	30/50	onion	onion smut	UNR
prometryne	*See GESAGARD*					
propamocarb/HCl/ chlorothalonil	*See TATTOO C*					

TABLE 6–2.
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WG = wettable granules
WP = wettable powder

Examples of Brand Name/ Trade Name[a]	Active Ingredient/ Common Name	Formulation	Guaranteed % Active Unless Stated	Crop Recommended Registrations	Target Pests	Company or Agent's code[b]
propiconazole	*See TOPAS*					
propyzamide	*See KERB*					
PROWL 400	pendimethalin	EC	400 g/L	onion	foxtail, crabgrass, barnyard grass, fall panicum, chickweed, lamb's quarters, pigweed	CYC
PURSUIT	imazethapyr	Sn	240 g/L	processing pea, snap bean	annual grasses & broadleaf weeds	CYC
PYRAMIN FL	pyrazon	Su	430 g/L	sugar beet, red beet	annual broadleaf weeds	BAZ
pyrazon	*See PYRAMIN*					
pyridate	*See LENTAGRAN*					
PYRIFOS	chlorpyrifos	Gr	15	same as Lorsban 15G	same as Lorsban 15G	UAG
PYRINEX	chlorpyrifos	EC	480 g/L	same as Lorsban 4E	same as Lorsban 4E	UAG
QUINTOZENE	quintozene (PCNB)	WP	75	broccoli, Brussels sprouts, cabbage, cauliflower	clubroot	PLG
quizalofop-p-ethyl	*See ASSURE II*					
REFLEX	fomesafen	Sn	240 g/L	bean (white, kidney, snap)	some annual broadleaf weeds	ZNA
REGLONE	diquat	Li	200 g/L	potato vine killing, adzuki bean, stale seedbed and inter-row weeding	any green foliage	ZNA
REGLONE A	diquat (aquatic)	Li	200 g/L	aquatic weed control	coontail, water weed, pondweed, milfoil, duckweed	ZNA
RENEGADE	glyphosate	Sn	356 g/L	preplant or post-harvest with no cropping restrictions; pre-harvest in peas	annual grasses & weeds; perennial weeds	MOL
RIDOMIL GOLD	metalaxyl-M	EC	480 g/L	snap bean	*Pythium* & *Phytophthora* root rot	NOV
RIDOMIL/BRAVO	metalaxyl/ chlorothalanil	EC	240/500 g/L	potato	*Pythium* leak, pink rot	NOV
RIDOMIL 2G	metalaxyl	Gr	2	carrot, lettuce	suppression of *Pythium*	NOV
RIDOMIL MZ GOLD	metalaxyl-M + mancozeb	WP	68	lettuce, onion,	downy mildew	NOV
				potato	*Pythium* leak, pink rot	
rimsulfuron	*See PRISM*					
RIPCORD	cypermethrin	EC	400 g/L	broccoli, Brussels sprout, cabbage, cauliflower, kale, lettuce, potato, sweet corn	various insects (check label and/or various crop sections)	ENG
RIVAL	trifluralin	EC	500 g/L	bean (snap, lima), peas (field & canning), turnip, carrot, direct seeded cabbage & cauliflower, transplants of tomato, pepper, Brussels sprout, broccoli, cabbage, cauliflower	annual grasses, pigweed, lamb's quarters	ARV
RIVAL DF		DF	60			
RO-NEET	cycloate	EC	720 g/L	red beet, spinach, sugar beet	crabgrass, barnyard grass, foxtail, yellow nut sedge, some annual weeds	ZNA
RONILAN	vinclozolin	DF	50	bean, lettuce	*Sclerotinia* white mould	BAZ
ROTENONE	rotenone	WP	5	cucumber, melon, pumpkin, squash	cucumber beetle, squash vine borer	WIL
ROTENONE DUST		D	1			
ROUNDUP	glyphosate	Sn	356 g/L	same as Renegade	same as Renegade	MOL
ROUNDUP DRY		SG	64			
ROUNDUP FASTFORWARD PRESEED	glyphosate/ glufosinate ammonium	Sn	(30:1) 310 g/L	same as Renegade	same as Renegade	MOL

TABLE 6–2.
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Examples of Brand Name/ Trade Name[a]	Active Ingredient/ Common Name	Formulation	Guaranteed % Active Unless Stated	Crop Recommended Registrations	Target Pests	Company or Agent's code[b]
ROVRAL	iprodione	WP	50	bean	*Sclerotinia* white mould	RHQ
				cabbage, cauliflower	*Alternaria* leaf spot	
				garlic	*Penicillium* green mould	
				lettuce	*Botrytis* gray mould	
				onion	*Botrytis* leaf blight, downy mildew	
ROYAL MH 60	maleic hydrazide	SG	60	dry onion, potato	sprout inhibitor	UNR
SELECT	clethodim	EC	240 g/L	onion, potato	annual grasses	RHQ
SENATOR PSPT	thiophanate-methyl	D	10	potato seed piece	fungal decay	ENG
SENCOR 500 F	metribuzin	Su	500 g/L	asparagus, potato, transplant tomato	grasses & broadleaf weeds	BBB
SENCOR 75 DF		DF	75			
SENCOR SOLUPAK		WG	75			
sethoxydim	*See POAST ULTRA*					
SEVIN XLR PLUS	carbaryl	Su	480 g/L	asparagus, bean, broccoli, Brussels sprout, cabbage, cauliflower, kale, kohlrabi, carrot, celery, cucumber, melon, pumpkin, squash, eggplant, horseradish, lettuce, endive, parsley, pepper, potato, radish, rutabaga, sweet corn, tomato, Chinese cabbage, mustard greens	various insects (check label and/or various crop sections)	RHQ
SIMADEX	simazine See PRINCEP NINE T also	Su	500 g/L	asparagus, sweet corn	annual grasses, broadleaf weeds & some perennial weeds	ARV
SIMAZINE 480		Su	480 g/L			UAG
SIMAZINE 80W		WP	80			
SINBAR	terbacil	WP	80	asparagus, peppermint, spearmint	annual grasses, some broadleaf weeds & some perennial weeds	DUQ
s-metolachlor	*See DUAL MAGNUM*					
s-metolachlor/ benoxacor	*See DUAL MAGNUM II*					
s-metolachlor/ benoxacor/ atrazine	*See PRIMEXTRA II MAGNUM*					
SNIPER	azinphos methyl	WP	50	same as Guthion	same as Guthion	UAG
SNIPER 240		EC	240 g/L			
SPIN-AID	phenmedipham	EC	150 g/L	red beet	lamb's quarters, foxtail, wild buckwheat, mustard	ARV
STREPTOMYCIN 17	streptomycin sulphate	WP	17	broccoli, Brussels sprout, cabbage, cauliflower	seed treatment: black rot	UAG
sulphur	*See MICRONIASUL, MICROSCOPIC SULPHUR*					
SUPERIOR 70 OIL	mineral oil	Li	99	rutabaga	aphid feeding deterrent	UAG
TATTOO C	propamocarb HCl/ chlorothalonil	EC	(1:1) 375 g/L	potato	early & late blight	ARV
TELONE C17R	dichloropropene/ chloropicrin	Li	78/16.5	non-crop areas	nematodes, some diseases	DWE
TELONE II	1,3 dichloropropene	Li	94	as above	nematodes	DWE
terbacil	*See SINBAR*					
terbufos	*See COUNTER*					
TERR-O-GAS 67	methyl bromide/ chloropicrin	Li	67/31	greenhouse seedbeds	weeds	GRC

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Examples of Brand Name/ Trade Name[a]	Active Ingredient/ Common Name	Formulation	Guaranteed % Active Unless Stated	Crop Recommended Registrations	Target Pests	Company or Agent's code[b]
THIMET	phorate	Gr	15	potato	Colorado potato beetle	CYC
THIODAN	endosulfan	WP	50	celery, cucumber, melon, pumpkin, squash, eggplant, pepper, potato, spinach, tomato	various insects (check label and/or various crop sections)	ARV
THIODAN 4	endosulfan	EC	400 g/L	bean, broccoli, Brussels sprout, cabbage, cauliflower, celery, cucumber, melon, pumpkin, squash, eggplant, head lettuce, pepper, potato, rutabaga, spinach, sugar beet, tomato	as above	ARV
THIONEX	endosulfan	EC	400 g/L	same as Endosulfan	same as Endosulfan	UAG
thiophanate-methyl	*See SENATOR PSPT*					
THURICIDE	Bacillus thuringensis	Li	4,000/mg	broccoli, Brussels sprout, cabbage, cauliflower, kale, lettuce, celery, mustard greens, spinach, tomato	cabbageworm, cabbage looper, diamondback moth, beet webworm, hornworm	NOR
TOPAS	propiconazole	EC	250 g/L	rutabaga	powdery mildew	ENG
				sweet corn	rust	
TOUCHDOWN 480	glyphosate TMS	Sn	330 g/L	same as Roundup & Renegade, except no preharvest uses	same as Roundup & Renegade	ZNA
TREFLAN	trifluralin	EC	545 g/L	same as Rival	same as Rival	DWE
TREFLAN EC		EC	480 g/L			
triallate	*See AVADEX BW*					
trifluralin	*See BONANZA, RIVAL, TREFLAN*					
triflusulfuron-methyl	*See UPBEET*					
TROPOTOX PLUS	MCPB/MCPA	Sn	400 g/L	pea	broadleaf weeds	RHQ
TUBERSEAL	mancozeb	D	16	potato seed piece	*Fusarium*	NOR
UPBEET	triflusulfuron-methyl	DF	50	sugar beet	velvetleaf	DUQ
VAPAM	metam sodium	Sn	380 g/L	same as Busan	same as Busan	UAG
vinclozolin	*See RONILAN*					
VORLEX PLUS	methyl isothiocyanate/ dichloropropene	Li	203 g + 373 g/L	pre-plant treatment	weeds, some nematodes & fungi, wireworm	ARV
VORLEX PLUS CP	methyl isothiocyanate/ dichloropropene/ chloropicrin	Li	185 g + 370 g + 163 g/L	as above	as above	ARV
VYDATE	oxamyl	Li	240 g/L	potato	various insects (check label and/or potato section)	DUQ
WRANGLER	glyphosate	Sn	356 g/L	same as Renegade, Laredo, etc.	same as Renegade, Laredo, etc.	MOL
ZINEB	zineb	WP	80	asparagus	rust	UAG
				broccoli, Brussels sprout, cabbage, cauliflower	downy mildew	
				carrot, celery	leaf blight	
				lettuce	downy mildew	
				onion	*Botrytis* leaf blight, downy mildew, purple blotch	

[a] Mention of a brand or trade name in this table does not constitute a guarantee or warranty of the product by the Ontario Weed Committee or the Ontario Crop Protection Committee nor that these products are approved to the exclusion of comparable products. All trade names are capitalized.
[b] See Table 6–2a. on page 178.

Table 6–2a. Pest Control Product Companies

Code	Company/Agent	Web site	Contact Number
****	Various manufacturers		
ABT	Abbott Laboratories Ltd.	www.abbott.com/about/namerica.htm	1-800-384-2474
APB	Applied Biochemists Inc.	www.appliedbiochemists.com/	1-800-558-5106
ARV	Agrevo Canada Inc.	www.ca.agrevo.com/	1-800-667-5959
BBB	Bayer Inc.	www.bayer.ca/	1-800-268-1331
BAZ	Basf Canada Inc.	www.basf.com/businesses/consumer/agproducts/	1-800-565-9586
BUL	Buckman Laboratories of Canada Ltd.		(450) 424-4404
CAU	Cheminova Canada	www.cheminova.com/	1-888-316-6260
CPM	Cooper Mill Ltd	www.coopermill.com	(613) 473-4847
CYC	Cyanamid Crop Protection	www.farmlinepartners.com/	1-800-263-1228
DUQ	Dupont Canada Inc.	www.dupont.ca/ag/	1-800-667-3925
DWE	Dow Agrosciences Canada Inc.	www.dowagro.com/canada/	1-800-667-3852
EFA	Elf AtoChem of Canada Ltd.	www.elf-atochem.com/newelf/homepage.cfm	(905) 827-9841
ENG	Engage Agro Inc.	www.engageagro.com	(519) 826-7878
GRC	Great Lakes Chemical Corporation	www.greatlakescorp.com/	(773) 478-3625
GRN	Griffin Corporation	www.griffinllc.com	(519) 894-4632
MOL	Monsanto Canada Inc.	www.farmcentral.com	1-800-667-4944
NID	Novo Nordisk BioIndustrials Inc.		(416) 920-7766
NOR	Norac Concepts Inc.	www.noracconcepts.com	(613) 841-2907
NOV	Novartis Crop Protection Inc.	www.cp.ca.novartis.com/	1-800-459-2422
NUA	NuFarm Agriculture Inc.	www.nufarm.com/usa-top-frame.htm	1-800-868-5444
PLG	Plant Products Co. Ltd.	www.plantprod.com/	1-800-387-2449
RHQ	Rhone-Poulenc Canada Inc.	www.rp-ag.com	1-800-891-8291
ROH	Rohm & Haas Canada Inc.	www.rohmhaas.com/agcanada/	1-800-268-4201
STD	StanChem Inc.		(416) 259-8231
TMO	Tomen Agro	www.tomenagro.ca/	(519) 766-1117
UAG	United Agri-Products	www.uap.ca	1-800-265-4624
UNR	Uniroyal Chemical	www.uniroyalchemical.com/	1-800-265-2157
VAR	Van Waters & Rogers	www.vwr-ltd.com/	1-800-265-7671
WBR	Wilbur Ellis Co. of Canada Ltd.	www.wilburellis.com/	(306) 242-4553
WIL	Wilson Laboratories		(905) 639-7535
ZNA	Zeneca Agro	www.zeneca.ca	1-800-797-5040

Ontario Classification Schedule

Listed, right, are the schedules in which the brand name products in Table 6–2, *Pesticides Used on Vegetable Crops in Ontario,* on page 167, are classified under the *Pesticides Act.* The majority of materials listed for vegetables are classified as Schedule 2 or 5. Consult your local pest control product supplier or, for more information, contact the Ministry of the Environment office nearest you.

TABLE 6–3.
Explanation of Schedules

Schedule 1	Restricted. Use permit only.
Schedule 2	Restricted to certified agriculturists, licensed exterminators, registered custom sprayer and permit holders.
Schedule 3	Agriculturists and consumer use.
Schedule 4	Domestic products only.
Schedule 5	Limited to application on agricultural land. Similar to Schedule 2.
Schedule 6	Similar to Schedule 4 but may be registered for agricultural/commercial use, container size 1 L or greater.

TABLE 6–4.
Herbicide Groupings for Ontario

Group[a]	Site of Action	Single modes of action (alphabetic order)	Two or more modes of action (alphabetic order)[b]
1	Inhibitors of acetyl CoA carboxylase (ACCase)	Acclaim Super, Achieve, Assure, Assure II, Excel Super, Fusilade II, Hoe-grass 284, Poast Ultra, Select, Venture 25G	
2	Inhibitors of acetolactate synthase (ALS) and also called acetohydroxyacid synthase (AHAS)	Accent, Arsenal, Classic, Elim EP, Muster, Pinnacle, Peak, Prism, Pursuit, Refine Extra, Reliance STS, Telar, Ultim, Viper	Broadstike Dual (2,15), Broadstike Treflan (2,3), Conquest[c] (2,5), Fieldstar (2,4), Patriot (2,5), PeakPlus[c] (2,4), Striker (2,4), Ultimax[c] (2,4), Valor (2,3), Viper[c] (2,14)
3	Microtubule assembly inhibitors	Edge, Bonanza 400, Dimension, Prowl, Rival, Treflan	Broadstrike Treflan (2,3), Valor (2,3)
4	Synthetic auxins	Banvel II, Caliber 400, Cobutox 600, Compitox, Covitox Plus, Dichlorprop-D, Diphenoprop, Dycleer, Dyvel, Embutox 625, Estaprop, Estasol, Estamine 2,4-D, Ester, Expedite Broadleaf, Garlon 4, Kil-Mor, Killex, Lontrel, MCPA, Mecoprop, Mecocrop 2,4-D, Mecoturf Plus 2,4-D, Meco-D, Par III, Premium 3-Way, Release, See 2,4-DB, Target, Tordon 101 mix, Tricep, Turf Herbicide, Turf-Rite 2+2, Turboprop, Weedone CB	Buctril M (4,6), Calmix Pellets (4,5), Distinct (2,19), Fieldstar (2,4), Marksman (4,5), PeakPlus[c] (2,4), Shotgun (4,5), Stampede CM (4,7), Striker (2,4), Ultimax[c] (2,4),
5	Inhibitors of photosynthesis at photosystem II, Site A	Aatrex, Atrazine, Bladex, Gesagard, Hyvar X, Lexone, Princep Nine-T, Pronone, Pyramin FL, Sencor, Simadex, Simazine, Sinbar, Velpar	Calmix Pellets (4,5), Conquest[c] (2,5), Krovar (5,7), Laddok (5,6), Marksman (4,5), Patriot (2,5), Primextra II Magnum (5,15), Primextra Light (5,15), Shotgun (4,5),
6	Inhibitors of photosynthesis at photosystem II, Site A	Basagran, Basagran Forte, Lentagran, Pardner	Buctril M (4,6), Laddok (5,6)
7	Inhibitors of photosynthesis at photosystem II, Site B	Afesin, Afolan F, Betamix, Betanex, Herbec 20P, Karmex, Linuron 480, Lorox, Patoran FL, Spin-Aid	Krovar (5,7), Stampede CM (4,7)
8	Conjugation of acetyl co-enyme A	Avadex BW, Avenge 200C, Betasan, Eradicane, Eptam, Ro-Neet	
9	Inhibitors of 5-enolpyruvylshikimimate-3-phosphate synthase (EPSP)	Clear-It, Credit, Expedite Grass & Weed, EZJect, Glyfos, Laredo, Renegade, Roundup, Touchdown 480, Vantage, Vision, Wrangler	Roundup Fast Forward (9,10)
10	Inhibitors of glutamine synthetase	Liberty 200 SN, Ignite	Roundup Fast Forward (9,10)
11	Inhibitors of carotenoid biosynthesis	Amitrol 240, Amitrol-T	
14	Inhibitors of protoporphyrinogen oxidase (Protox)	Blazer, Goal 2XL, Reflex, Ronstar 2G	Viper[c] (2,14)
15	Conjugation of acetyl co-enyme A	Devrinol, Dual, Dual Magnum, Dual II Magnum, Frontier	Broadstrike Dual (2,15), Primextra II Magnum (5,15), Primextra Light (5,15)
19	Inhibitors of auxin transport system	Alanap,	Distinct (2,19)
20	Inhibits cell wall synthesis, Site A	Casoron 4G	
22	Photo system I - electron diverters	Gramoxone, Reglone, Reglone A, Weed & Grass Killer	
23	Inhibitors of mitosis	CIPC	
27	others	Basamid, Krenite, Vapam	
28	Inhibitors of p-hydroxyphenyl pyruvate dioxygenase (HPPD)		

[a] Herbicide groupings for Ontario follow the Weed Science Society of America's nationally accepted grouping. Since Groups 12, 13, 16, 17, 18, 21, 24, 25 and 26 are not available in Ontario, they have been removed to simplify the chart.

[b] Products with two or more sites of action are followed by the group numbers involved.

[c] Herbicides sold as a co-pack under this trade name.

TABLE 6–5.
Interval Before Rainfall (Post-Emergent Herbicides)

0 to 15 Minutes	1 Hour	2 Hours	3 Hours	4 Hours	6 Hours	8 Hours
GRAMOXONE	ASSURE II	ACCENT	GOAL 2XL	2,4-D AMINE	AMITROL 240	AFOLAN F
REGLONE	EXCEL SUPER	atrazine		BASAGRAN	LINURON 480	
	HOE-GRASS 284	BLADEX (L and DF)		IGNITE	LOROX	
	PARDNER	FUSILADE II		LONTREL	BETAMIX	
	POAST ULTRA	LENTAGRAN		REFLEX	BETANEX	
	SELECT	PRISM		ROUNDUP TRANSORB	BLAZER	
		PURSUIT		TROPOTOX PLUS	GLYFOS	
				UPBEET	LADDOK	
					LEXONE	
					PYRAMIN FL	
					ROUNDUP	
					SENCOR	
					SPIN-AID	
					TOUCHDOWN	

Interval Before Rainfall

Rainfall shortly after application of a postemergent herbicide may reduce the weed control. This effect will vary with the product, the formulation, the interval of time and the drying conditions between applications and rainfall, as well as on the amount, intensity and duration of rainfall. The information in Table 6–5, *Interval Before Rainfall (Post-Emergent Herbicides)*, above, is based on label information and additional detail supplied by the chemical industry. In the case of a tank mix, use the longest time interval of the products being considered. For further information, contact the manufacturer.

Crop Rotation

Table 6–6, *Herbicide Crop Rotation and Soil pH Restrictions for Horticultural Crops*, on page 181 and Table 6–7, *Herbicide Crop Rotation and Soil pH Restrictions for Field Crops*, on page 182, show the recommended periods of time between application of herbicides and planting of horticultural and field crops.

TABLE 6–6.
Herbicide Crop Rotation and Soil pH Restrictions for Horticultural Crops

(For other crops, consult the label.)

Trade name	Asparagus	Beans, lima	Beans, snap	Beets, red	Beets, sugar	Broccoli	Brussels sprouts	Cabbage	Carrots	Cauliflower	Celery	Corn, sweet	Cucumber	Garlic	Herbs	Lettuce	Muskmelon	Onions	Parsnips	Peas	Peppers	Potatoes	Pumpkin	Rutabaga	Spinach	Squash	Tomatoes (transplanted)	Watermelon
	Number of months between application and planting.																											
ACCENT	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ
ATRAZINE <1.0 kg ai/ha	22	10	10	22	22	22	22	22	22	22	22	—	22	22	22	22	22	22	22	10	22	10	22	22	22	22	10	22
ATRAZINE > 1.0 —1.5 kg ai/ha	22	22	22	22	22	22	22	22	22	22	22	—	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
BROADSTRIKE DUAL	ƒ	10	10	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	22	22	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	10	22	22	ƒ	ƒ	ƒ	ƒ	26	ƒ
BROADSTRIKE TREFLAN	ƒ	10	10	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	22	22	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	10	22	22	ƒ	ƒ	ƒ	ƒ	26	ƒ
CLASSIC (Soil pH 7.4 and less)	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ
CLASSIC (Soil pH 7.4 to 7.8)	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ
CONQUEST[a]	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
FIELDSTAR	ƒ	10	10	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	22	22	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	10	ƒ	26	ƒ	ƒ	ƒ	ƒ	26	ƒ
FRONTIER	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	—	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ
LEXONE, SENCOR	—	10	10	22	22	22	22	22	10	22	22	10	22	10	10	22	22	22	10	10	22	—	22	22	22	22	—	22
LONTREL	22	22	22	22	—	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	—	22	22	22	22
MUSTER	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ
PATRIOT	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	10	22	22	22	22	22	22	22	22
PEAK, PEAKPLUS[a]	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	10	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ
PRISM, ELIM EP	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	—	ƒ	ƒ	ƒ	ƒ	—	ƒ
PROWL	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	—	22	22	22	22	22	22	22	22	22	22
PURSUIT	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	—	22	22	22	22	22	22	22	22
REFLEX	ƒ	ƒ	—	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ
RELIANCE STS (Soil pH 7.4 and less)	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ
RELIANCE STS (Soil pH 7.4 to 7.8)	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ
SIMAZINE, PRINCEP<2 kg ai/ha	22	22	22	10	22	22	22	22	22	22	22	10	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
SIMAZINE, PRINCEP>2 kg ai/ha	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
STRIKER	ƒ	10	10	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	22	22	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	10	ƒ	26	ƒ	ƒ	ƒ	ƒ	26	ƒ
ULTIM	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ
ULTIMAX[a]	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ
VALOR	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
VIPER[a]	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	ƒ	10	ƒ

— = Registered for use ƒ = Field bioassay, user assumes liability for all crops not listed on label.

[a] Herbicides sold as a co-pack under this trade name.

TABLE 6–7.
Herbicide Crop Rotation and Soil pH Restrictions for Field Crops

(For other crops, consult the label.)

Trade name	Alfalfa	Barley	Barley (underseeded)	Beans, kidney	Beans, white	Canola, including RR	Canola, IMI Smart	Clover, red	Corn, field, including RR, LL, PP	Corn, CL	Corn, seed	Flax-linseed	Oats	Oats (underseeded)	Peanuts	Rye, fall	Rye, fall (underseeded)	Soybeans	Sunflowers	Tobacco	Wheat, spring	Wheat, spring (underseeded)	Wheat, winter	Wheat, winter (underseeded)
	Number of months between application and planting																							
ACCENT	10	10	10	*f*	10	10	10	10	–	–	*f*	*f*	*f*	*f*	*f*	*f*	*f*	10	*f*	*f*	*f*	*f*	4	4
ATRAZINE <1.0 kg ai/ha	10	10	10	10	10	22	22	10	–	–	–	10	10	10	22	10	10	10	22	22	10	10	4	10
ATRAZINE > 1.0–1.5 kg ai/ha	22	10	22	22	22	22	22	22	–	–	–	10	22	22	22	10	22	10	22	22	10	22	10	22
BROADSTRIKE DUAL, BROADSTRIKE TREFLAN (Soil pH > 7.8 and OM < 2%)	10	10	*f*	10	10	26	26	10	10	10	10	*f*	10	*f*	*f*	*f*	*f*	–	*f*	*f*	10	*f*	4	*f*
CLASSIC (Soil pH 7.4 and less)	10	10	*f*	*f*	10	*f*	*f*	*f*	10	10	*f*	*f*	*f*	*f*	*f*	*f*	*f*	10	*f*	*f*	*f*	*f*	3	*f*
CLASSIC (Soil pH 7.4 to 7.8)	22	22	*f*	*f*	10	*f*	*f*	*f*	22	22	*f*	*f*	*f*	*f*	*f*	*f*	*f*	10	*f*	*f*	*f*	*f*	3	*f*
CONQUEST[a]	22	10	22	22	22	22	22	22	10	10	22	22	22	22	22	22	22	–	22	22	10	22	4	22
ELIM, PRISM	*f*	10	10	*f*	10	10	10	10	–	–	*f*	*f*	*f*	*f*	*f*	*f*	*f*	10	*f*	*f*	*f*	*f*	4	4
FIELDSTAR (Soil pH < 5.9 or > 7.8)	10	10	*f*	10	10	26	26	10	–	–	10	*f*	10	*f*	*f*	*f*	*f*	10	*f*	*f*	10	*f*	4	*f*
FRONTIER	10	10	10	–	–	10	10	10	–	–	0	10	10	10	10	10	10	–	10	10	10	10	4	10
LEXONE, SENCOR (Soil pH > 7.5)	10	10	10	10	10	22	22	10	–	–	10	10	10	10	10	10	10	–	10	22	10	10	3.3	10
LONTREL	22	10	22	22	22	10	10	22	22	22	22	10	10	22	22	10	22	22	22	22	10	22	10	22
MUSTER	*f*	10	*f*	*f*	*f*	–	–	*f*	*f*	*f*	*f*	*f*	10	*f*	*f*	*f*	*f*	10	*f*	*f*	10	*f*	4	*f*
PATRIOT	22	10	22	10	10	22	22	22	10	–	22	22	22	22	22	22	22	22	22	22	10	22	4	22
PEAK, PEAKPLUS[a]	22	10	*f*	*f*	10	*f*	*f*	*f*	–	–	*f*	*f*	10	*f*	*f*	*f*	*f*	10	*f*	*f*	*f*	*f*	*f*	*f*
PURSUIT	–	10	22	–	–	22	–	22	10	–	22	22	22	22	22	22	22	–	22	22	10	22	3.3	22
REFLEX	*f*	*f*	*f*	–	–	18	18	*f*	10	10	*f*	*f*	*f*	*f*	*f*	*f*	*f*	–	*f*	*f*	10	*f*	4	*f*
RELIANCE STS (Soil pH 7.4 and less)	10	*f*	*f*	*f*	10	*f*	*f*	*f*	10	10	*f*	*f*	*f*	*f*	*f*	*f*	*f*	10	*f*	*f*	*f*	*f*	3	*f*
RELIANCE STS (Soil pH 7.4 to 7.8)	22	22	*f*	*f*	10	*f*	*f*	*f*	22	22	*f*	*f*	*f*	*f*	*f*	*f*	*f*	10	*f*	*f*	*f*	*f*	3	*f*
STRIKER	10	10	*f*	10	10	26	26	10	–	–	10	*f*	10	*f*	*f*	*f*	*f*	10	*f*	*f*	10	*f*	4	*f*
ULTIM	*f*	10	10	*f*	10	10	10	10	–	–	*f*	*f*	*f*	*f*	*f*	*f*	*f*	10	*f*	*f*	*f*	*f*	4	4
ULTIMAX[a]	*f*	10	*f*	*f*	*f*	*f*	*f*	*f*	–	–	*f*	*f*	*f*	*f*	*f*	*f*	*f*	10	*f*	*f*	*f*	*f*	4	*f*
VALOR	18	18	18	18	18	18	18	18	10	10	18	18	18	18	18	18	18	–	18	18	18	18	18	18
VIPER[a]	*f*	*f*	*f*	*f*	*f*	*f*	*f*	*f*	10	10	*f*	*f*	*f*	*f*	*f*	*f*	*f*	–	*f*	*f*	*f*	*f*	4	*f*

– = Registered for use *f* = field bioassay, user assumes liability for all crops not indicated on label.

[a] Sold as a co-pack under this trade name.

TABLE 6–8.
Non-Selective Herbicides Available for Preplant Site Preparation

CROP	BASAMID	GRAMOXONE	IGNITE	REGLONE	GLYFOS, ROUNDUP TRANSORB, TOUCHDOWN 480	VAPAM	VORLEX PLUS/ PLUS CP
Field vegetable seedbeds	X				X	X	
Stale seed seds		X			X		
Asparagus			X		X		X
Beans				X	X		X
Beets			X	X	X		
Carrots			X	X	X		
Celery					X		X
Cole crops				X	X		
Corn				X	X		
Cucumber				X	X		
Eggplant	X				X		X
Ginseng					X		X
Lettuce	X		X		X		X
Melons					X		
Onions			X	X	X		X
Peas				X	X		
Peppers	X				X		
Potatoes				X	X		X
Rutabaga				X	X		
Squash					X		X
Tomato	X				X		X

TABLE 6–9.

Preplant Herbicide Weed Control Ratings

The chemical ratings in this chart give general comparisons based on use as described in this guide. Under unfavourable conditions (e.g., too dry, too wet, too cold or poor application), the herbicides may not be as effective as indicated. Weed control ratings are given as 0–9, where 0 indicates no control, and 9 indicates 90–100% control under ideal conditions. Ratings are dependant upon rates and timing. Please see product label for information on registered weed species, product uses and precautions.

				Perennials															
Treatment	Trade Name	annual grasses	annual broadleaves	bindweed, field	chickweed, mouse-eared	dandelion	golden-rod	ground-ivy (creeping Charlie)	horsetail	mallow	milkweed	nutsedge	plantains	poison ivy	quackgrass	sow-thistle	thistle, Canada	vetches
Preplant																		
amitrole	AMITROL 240	**	**	[a]	?	9	[a]	?	7	?	[a]	[a]	8	8	7	[a]	7	?
glyphosate	CREDIT, GLYPHOS, ROUNDUP, TOUCHDOWN	**	**	7	9	7	0	5	0	5	[a]	7	8	8	8	[a]	7	5
glufosinate ammonium	IGNITE	**	**	8 [b]	?	8	?	?	7 [b]	?	6 [b]	7 [b]	?	?	8 [b]	8 [b]	8 [b]	?
paraquat	GRAMOXONE	**	**	[c]	[c]	[c]	?	[c]	[c]	[c]	[c]	0	[c]	[c]	5	[c]	0	[c]

** = Most annual weeds will be controlled if emerged. ? = Insufficient information available to make a rating.

[a] Optimum growth stages for best control of these weeds will not likely be attained prior to planting in early to mid-spring.
[b] Repeated applications may be necessary.
[c] Top growth only, regrowth can be expected.

PREPLANT WEED AND COVER CROP CONTROL

Cover crops and emerged weeds which must be controlled before a vegetable crop is seeded or transplanted are usually controlled with glyphosate (0.75 to 3.5 L/ha) a translocated systemic herbicide, with paraquat (GRAMOXONE) or diquat (REGLONE) at 3.0 to 5.5. L/ha (1.2-2.2 L/ac), both contact, non-systemic herbicides or with glufosinate ammonium (IGNITE) at 2.7 to 5.0 L/ha (1.08-2 L/ac), a minimal translocation, mostly contact, non-systemic herbicide. All four herbicides are non-residual. Glyphosate (ROUNDUP or TOUCHDOWN) can be used before planting any vegetable crops. Paraquat (GRAMOXONE) or diquat (REGLONE) are registered for preplant use on beans, beets, carrots, cole crops, onions, peas, potatoes, sweet corn and rutabagas. Glufosinate ammonium (IGNITE) is registered for preplant use on carrot, lettuce and onions only.

A stale seedbed technique involves preparing a seedbed early in the growing season, controlling emerged weeds several weeks later with glyphosate, paraquat, diquat or glufosinate ammonium, then seeding or transplanting vegetable crops trying to prevent disturbing the soil as little as possible to delay the emergence of new crop of weeds.

Alternatively, a grower may choose to kill the cover crop or/and emerged weeds just before planting the vegetable crop and either till the area or leave seedbed untilled.

Inter-row weeding with a contact herbicide such as paraquat (3 to 5.5 L/ha (1.2-2.2 L/ac) (product) in 250 to 1000 L/ha (100-400 L/ac) water) can be used as a rescue operation where other methods of weed control have failed. The herbicide is directed between the crop rows onto the emerged weeds. Use special low pressure (7 to 15 kPa) applicators such as dribble bars or vibra jets equipped with shields to prevent wetting the crop. This technique of weeding with paraquat is registered for use on beans, beets, carrots, cole crops, cucumbers, lettuce, onions, potatoes, sweet corn and tomatoes.

PREPLANTING TREATMENTS

Preplanting treatments are applied before the crop is sown or planted. Some of these herbicides kill seedlings soon after germination while others also kill weed seeds. Most herbicides used for these treatments must be thoroughly incorporated in the soil by cultivation soon after application. Check the label.

SELECTIVE PREEMERGENCE HERBICIDES

These materials prevent emergence of many weed seedlings without reducing crop stand. This type of material should be applied immediately after seeding or at least before the emergence of the crop. If these materials are applied after weeds have emerged, kill is usually poor. Best results are obtained with this method when conditions for weed seed germination are good.

SELECTIVE POSTEMERGENCE HERBICIDES

These chemicals are applied after the crop plants have sprouted, or after the crop has been transplanted. Applied as directed, the weeds can be killed without injury to the crop. The weeds should be small for best results.

Active Ingredient TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACRE	PRECAUTIONS (For more information, see "Notes on Chemicals" section.)
Asparagus			
PREPLANT - See under **PREPLANT - SITE PREPARATION** for details of products, rates and remarks.			
PREPLANT INCORPORATED - Two incorporations at right angles operating at a depth of 10 cm using a double disk (7-10 km/hour) or vibrating shank S-tine cultivator (10-13 km/hour) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness, and/or treating fields with perennial weeds last.			
PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.			
[redacted]			
glufosinate ammonium IGNITE (150g/L)	0.405 to 0.75 kg/ha 2.7 to 5 L/ha	 1.08 to 2 L/ac	Apply in 110-330 L/ha (44-132 L/ac) water. Spray on emerged weeds prior to emergence of the crop. Weeds which have not emerged will not be controlled. Ensure uniform coverage. See label for more detailed information.
paraquat GRAMOXONE (200g/L) followed by napropamide DEVRINOL DF (50 DF)	0.6 to 1.1 kg/ha 3 to 5.5 L/ha 2.25 to 4.5 kg/ha 4.5 to 9 kg/ha	 1.2 to 2.2 L/ac 1.8 to 3.6 kg/ac	Apply in 300 to 1100 L/ha (120-440 L/ac) water. Spray on emerged weeds before crop emergence. Apply preemergence treatment to next crop of weeds. Direct seeding of asparagus is only practical if weeds can be controlled from the time of seeding until the asparagus plants develop an extensive root system. Paraquat can be used as a "chemical mower" to kill emerged seedling weeds when the first asparagus seedlings are beginning to emerge. To note development, monitor germination progress of asparagus by frequent examination of germinating seeds. Soon after this application, the napropamide preemergence treatment should be made to extend the period of weed control. To be effective, this must be separate applications.
terbacil SINBAR (80 WP)	0.3 kg/ha 0.38 kg/ha	 0.15 kg/ac	Plant asparagus seed into newly cultivated fields, where no weeds have emerged. Asparagus seed should be planted to a depth of 4 cm in coarse (sandy) soils, or 2.5 cm deep in fine (clay) soils. Within 2 days of planting, apply a preemergent broadcast application of SINBAR at a rate of 0.38 kg/ha (0.15 kg/ac). See label for more details.
[redacted]			
fluazifop-p-butyl FUSILADE II (125g/L)	0.075 to 0.25 kg/ha 0.6 to 2 L/ha	 0.24 to 0.8 L/ac	Apply at 0.6 L/ha (0.24 L/ac) at 2-5 leaf stage of annual grasses. Apply at 0.8 L/ha (0.32 L/ac) at 2-5 leaf stage of volunteer wheat and barley. Apply at 1 to 2 L/ha (0.4-0.8 L/ac) at 3-5 leaf stage of quackgrass and wirestem muhly. Thorough preplant tillage, fragmenting quackgrass rhizomes improves control. Inter-row cultivation should not occur until 5 days after application.
[redacted]			
napropamide DEVRINOL DF (50 DF)	2.25 to 4.5 kg/ha 4.5 to 9 kg/ha	 1.8 to 3.6 kg/ac	Treat at planting time, or soon after planting before weed seedlings appear. Use lower rate on sandy soils and the higher rate on clay soils. Incorporation by irrigation or rainfall is essential.
[redacted]			
fluazifop-p-butyl FUSILADE II (125g/L)	0.075 to 0.25 kg/ha 0.6 to 2 L/ha	 0.24 to 0.8 L/ac	Apply at 0.6 L/ha (0.24 L/ac) at 2-5 leaf stage of annual grasses. Apply at 0.8 L/ha (0.32 L/ac) at 2-5 leaf stage of volunteer wheat and barley. Apply at 1 to 2 L/ha (0.4-0.8 L/ac) at 3-5 leaf stage of quackgrass and wirestem muhly. Thorough preplant tillage, fragmenting quackgrass rhizomes improves control. Inter-row cultivation should not occur until 5 days after application.

diuron KARMEX (80 DF)	1.75 to 2.25 kg/ha 2.19 to 2.81 kg/ha	 0.88 to 1.12 kg/ac	Disk before any shoots appear in the spring on established plantings. This may be followed by one of the following herbicides. Linuron, diuron, metribuzin, simazine or simazine plus napropamide should be applied immediately after the spring disking before weeds germinate in established asparagus. A second application may be made after the postharvest disking. CAUTION: The lower rates are recommended for lighter soils. Rates are given for overall sprays; reduce proportionately if only rows are sprayed. Extreme caution is needed if diuron or simazine is used in rotations where susceptible crops are to be grown one year after application.
glyphosate ROUNDUP (356g/L)	0.45 to 0.89 kg/ha 1.25 to 2.5 L/ha	 0.5 to 1 L/ac	For control of fall-seeded rye, apply in the spring before the spears emerge, but not closer than 7 days to harvest. Only 1 application per year may be used.
linuron LOROX DF (50 DF) AFOLAN F (480g/L) LINURON 480 (480g/L)	1.75 to 2.25 kg/ha 3.5 to 4.5 kg/ha 3.64 to 4.69 L/ha 3.64 to 4.69 L/ha	 1.4 to 1.8 kg/ac 1.46 to 1.88 L/ac 1.46 to 1.88 L/ac	See notes for diuron (KARMEX) above.
metribuzin SENCOR 75 DF (75 WG) LEXONE DF (75 DF)	1.1 to 2.25 kg/ha 1.46 to 3 kg/ha 1.46 to 3 kg/ha	 0.58 to 1.2 kg/ac 0.58 to 1.2 kg/ac	See notes for diuron (KARMEX) above.
simazine PRINCEP NINE-T (90WG) plus napropamide DEVRINOL 50W (50 WP)	1.1 to 2.2 kg/ha 1.2 to 2.4 kg/ha 4.5 to 6.7 kg/ha 9 to 13.4 kg/ha	 0.5 to 1 kg/ac 3.6 to 5.36 kg/ac	Apply preemergent to established beds. Make only one application per season. DO NOT apply within 6 days of harvest.
simazine PRINCEP NINE-T (90WG) SIMADEX (500g/L) SIMAZINE 480 (480g/L)	2.2 to 3.4 kg/ha 2.5 to 3.75 kg/ha 4.5 to 6.7 L/ha 4.7 to 7 L/ha	 1 to 1.5 kg/ac 1.8 to 2.68 L/ac 1.88 to 2.8 L/ac	Apply preemergence to crop, 7 days before first cutting. Use on established plantings of 3 years or older only.
terbacil SINBAR (80 WP)	0.3 kg/ha 0.375 kg/ha	 0.15 kg/ac	Apply 375 g/ha (150 g/ac) of SINBAR prior to spear emergence. Application may be made immediately after clean cutting. SINBAR must only be applied to established asparagus beds once throughout the entire growing season. Apply before annual weeds emerge, or to small, actively growing weeds (up to 5 cm tall or across). DO NOT use on soils containing less than 1% organic matter, or on areas where subsoil or roots are exposed. Crop injury may occur if SINBAR is used on plants that are weak or diseased, or lacking in vigor (slow growing). DO NOT harvest within 5 days of treatment. Treated areas may be replanted to asparagus the following year after application. DO NOT plant any other crop for 2 years. See label for further details.
[redacted]			
trifluralin TREFLAN (480g/L) RIVAL DF (60 DF) BONANZA 400 (400g/L)	1 to 2 kg/ha 2.08 to 4.16 L/ha 1.67 to 3.34 kg/ha 2.5 to 5 L/ha	 0.83 to 1.66 L/ac 0.67 to 1.33 kg/ac 1 to 2 L/ac	Application should occur early enough in the spring to ensure that spears are not injured by the required incorporation (5-10 cm). Apply after last cutting of spears (post harvest disking) and incorporate as indicated on the label. Use only on established plantings of three years or older.

Active ingredient TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACRE	PRECAUTIONS (For more information, see "Notes on Chemicals" section.)
paraquat GRAMOXONE (200g/L)	0.6 to 1.1 kg/ha 3 to 5.5 L/ha	1.2 to 2.2 L/ac	Apply in 300 to 1100 L/ha (120-440 L/ac) water. Paraquat should also be applied on weed seedlings before asparagus tips appear or after the last cutting. DO NOT apply to emerged spears which are to be used for human consumption. It is particularly effective for control of grass. Use the higher volume of water on dense weed growth.
2,4-D * 2,4-D (470g/L)	1.293 kg/ha 2.75 L/ha	1.1 L/ac	Apply in 50 to 200 L/ha (20-80 L/ac) water. May be applied early in the season just after a cutting. Consult product label for specific instructions for asparagus. Emerging spears may be twisted. Discard twisted spears. Later emerging spears will be normal. Spray immediately after a close harvest to avoid injury.
2,4-D * 2,4-D (470g/L)	0.94 to 1.293 kg/ha 2 to 2.75 L/ha	0.8 to 1.1 L/ac	Apply in 50 to 200 L/ha (20-80 L/ac) water. Apply 3 weeks after the post cutting disking. Direct spray to avoid wetting the asparagus fern. Consult label for specific instructions for asparagus.
fenoxaprop-p-ethyl EXCEL SUPER (80.5 g/L)	0.054 kg/ha 0.67 L/ha	0.27 L/ac	Apply to asparagus only after the spears have been harvested. DO NOT treat spears prior to or during harvest. Apply when majority of annual grasses are in the 1 to 6 leaf stage or until volunteer corn is up to 25 cm tall. Second flush annual grasses will not be controlled if emergence occurs after application.
glufosinate ammonium IGNITE (150g/L)	0.405 to 0.75 kg/ha 2.7 to 5 L/ha	1.08 to 2 L/ac	Apply in 110-330 L/ha (44-132 L/ac) water. Spray on emerged weeds prior to emergence of the crop. Weeds which have not emerged will not be controlled. Ensure uniform coverage. See label for more detailed information.

Beans (Snap & Lima)

All treatments should be applied in 150 to 300 L/ha (60-120 L/ac) water unless otherwise specified.

Cultivation, rotation and other cultural practices are effective weed control techniques that should be considered along with herbicide treatments when developing a weed control program. Any single method of weed control or the continuous use of the same chemical can lead to the build up of weeds resistant or tolerant to that control method. Rotation to other crops and/or other control methods will reduce thechance of developing new or unique weed infestations.

High speed (10-20 km/hr) shallow (2.5 to 3 cm) cultivation with a rotary hoe when the beans are in the 1 to 2 leaf stage will help to control small weed seedlings. This technique will not reduce herbicide action and may in some years enhance chemical weed control and improve crop safety.

Inter-row cultivation may be required when weeds escape herbicide treatment; weeds should be considered as escapes when they are 5 to 7 cm high. Cultivation should be shallow to prevent exposure of untreated soil and germination of new weed seeds.

Band treatment of chemical over the row will reduce costs by one-half to two-thirds, depending on the row spacing and width of band. Shallow inter-row cultivation will be required to control weeds between the bands.

Cultivation will give some control of established perennial weeds but may also help to spread them to previously uninfested areas. Machinery sanitation is important when moving from one field to another. Many perennials can be spread on tillage equipment. Where possible it is always a good idea to till fields with perennial weeds last. Custom operators should be particularly careful when moving from one farm to another. For additional information see the section on preventative weed control in this publication.

Some chemicals may also be impregnated on dry bulk fertilizer. Check the label for recommended fertilizer ingredients. Please refer to Beans (Snap & Lima) Weed Control Ratings Table to determine which market classes of edible beans are registered for the herbicide treatments listed.

Rates and application techniques vary for trifluralin products. For further information on these and other chemicals refer to label recommendations and also the "Notes on Chemicals" section in this publication.

PREPLANT - See under PREPLANT - SITE PREPARATION for details of products, rates and remarks.

PREPLANT INCORPORATED - Two incorporations at right angles operating at a depth of 10 cm using a double disk (7-10 km/hour) or vibrating shank S-tine cultivator (10-13 km/hour) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness, and/or treating fields with perennial weeds last.

PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

Soil Applied Grass Herbicides			
EPTC EPTAM (800g/L)	3.4 to 4.4 kg/ha 4.25 to 5.5 L/ha	1.7 to 2.2 L/ac	Apply Preplant incorporated. If dry weather has preceded the application of EPTC, delay seeding 7 to 10 days. Temporary injury can occur in the emerging crop. Use the high rate for nutsedge control
EPTC EPTAM (800g/L) plus trifluralin TREFLAN EC (480g/L) RIVAL (500g/L) BONANZA 400 (400g/L)	2.4 kg/ha 3 L/ha 0.6 kg/ha 1.25 L/ha 1.2 L/ha 1.5 L/ha	1.2 L/ac 0.5 L/ac 0.48 L/ac 0.6 L/ac	Apply Preplant incorporated. For snap beans only.

Active Ingredient TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACRE	PRECAUTIONS (For more information, see "Notes on Chemicals" section.)
s-metolachlor DUAL MAGNUM (915g/L)	1.05 to 1.6 kg/ha 1.15 to 1.75 L/ha	0.44 to 0.7 L/ac	Apply Preplant incorporated. S-metolachlor must be preplant incorporated before seeding the crop. Incorporation equipment should be set to work no deeper than 10 cm. DO NOT USE on muck, peat or high organic matter soils.
trifluralin TREFLAN EC (480g/L) DF (60 DF) BONANZA 400 (400g/L)	0.6 to 1.155 kg/ha 1.25 to 2.4 L/ha 1 to 1.9 kg/ha 1.5 to 2.75 L/ha	0.5 to 0.96 L/ac 0.4 to 0.76 kg/ac 0.6 to 1.1 L/ac	Apply Preplant incorporated. Incorporate as soon as possible and within 24 hours DO NOT exceed 1.2 L/ha (0.48 L/ac) of TREFLAN in medium textured soils and 1.7 L/ha RIVAL (0.68 L/ac) in heavy textured soils for lima beans.
Soil Applied Broadleaf Herbicides			
metobromuron PATORAN FL (400g/L)	1 to 1.7 kg/ha 2.5 to 4.25 L/ha	1 to 1.7 L/ac	Apply preemergent. DO NOT exceed 1.17 kg/ha (active) for kidney beans or snap beans. Beans should be seeded at least 5 cm deep. Injury may occur if beans are under stress or from treated soil having been splashed up onto the leaves by a rainstorm. A shallow harrowing or rotary hoeing after application of the chemical will reduce the possibility of splash up as well as help activate the chemical if dry weather follows application. Cultivation may be required with the low rate when applied sequentially after a preplant incorporated treatment.
monolinuron AFESIN (200g/L)	0.75 to 1.4 kg/ha 3.75 to 7 L/ha	1.5 to 2.8 L/ac	Apply preemergent. Do not use on soils less than 3% organic matter. Beans should be seeded at least 5 cm deep. Shallow planted crops may be injured if heavy rains follow application. A shallow harrowing or rotary hoeing after application of the chemical will reduce the possibility of splash up as well as help activate the chemical if dry weather follows. application. Use the low rate when applied sequentially after a preplant incorporated treatment.
Soil Applied Grass and Broadleaf Herbicides			
imazethapyr PURSUIT (240g/L)	0.075 kg/ha 0.312 L/ha	0.125 L/ac	Apply preemergent. Heavy infestations of ragweed or proso millet require a tank mix (see below). May be used on all soil types. Some rotational cropping restrictions. DO NOT use on Lima beans
imazethapyr PURSUIT (240g/L) plus metobromuron PATORAN FL (400g/L)	0.075 kg/ha 0.312 L/ha 1 to 1.2 kg/ha 2.5 to 3 L/ha	0.125 L/ac 1 to 1.2 L/ac	Apply preemergent. DO NOT use on Lima beans
Postemergent Grass Herbicides			
diclofop-methyl HOE-GRASS 284 (284g/L)	1 kg/ha 3.5 L/ha	1.4 L/ac	DO NOT apply if rain is expected within one hour after application. Apply when grasses are 1-4 leaf stage (2-3 is optimum).
fenoxaprop-p-ethyl EXCEL SUPER (80.5g/L)	0.054 kg/ha 0.67 L/ha	0.27 L/ac	Treat at the 1to 6 leaf stage of annual grass. Only for snap beans

sethoxydim	0.15 to 0.2 kg/ha		Use higher rate for volunteer spring cereals.
POAST ULTRA (450g/L)	0.32 to 0.47 L/ha	0.13 to 0.19 L/ac	Treat the 1 to 6 leaf stage of annual grass.
plus oil concentrate			Apply using 110 to 200 L/ha of water (44-80 L/ac).
ASSIST	2 L/ha	0.8 L/ac	
or surfactant			
MERGE	1 L/ha	0.4 L/ac	

Postemergent Broadleaf Herbicides

bentazon	0.84 to 1.08 kg/ha		No adjuvant is required with BASAGRAN FORTE.
BASAGRAN FORTE (480g/L)	1.75 to 2.25 L/ha	0.7 to 0.9 L/ac	For annual broadleaf weeds apply when beans are in unifoliate to 4th trifoliate leaf stage and weeds
or			are small and actively growing. Many annual broadleaf weeds are controlled including velvetleaf
BASAGRAN (480g/L)	1.75 to 2.25 L/ha	0.7 to 0.9 L/ac	(15 cm/up to 6 leaf), smartweed (20 cm/up to 10 leaf) and cocklebur (30 cm/up to 10 leaf). Use the
ASSIST	2 L/ha	0.8 L/ac	2.25 L/ha (0.9 plus oil concentrate L/ac) rate for annual broadleaf weeds.
			Two applications of 1.75 L/ha (0.7 L/ac) 10 days apart may be required to control the perennial weeds.
			BASAGRAN FORTE IS NOT REGISTERED FOR SNAP BEANS.

fomesafen	0.24 kg/ha		Apply early postemergence at 1-2 trifoliate to crop, when weeds are small and actively growing (2-4
REFLEX (240 g/L)	1 L/ha	0.4 L/ac	leaf stage).
plus adjuvant			Use higher rates of water and pressure for a heavy weed or crop canopy. Some bronzing may occur to
AGRAL 90	0.25 % v/v	0.25 % v/v	bean leaves at the time of application, but plants outgrow these effects without harming maturity or yield.
			Apply in 200-350 L/ha water (80-140 L/ac)
			DO NOT apply REFLEX to any field more often than once every two years.
			DO NOT apply to crop under stress.
			Some rotational cropping restrictions apply.
			For snap beans only.

Postemergent Grass and Broadleaf Herbicides

fenoxaprop-p-ethyl	0.054 kg/ha		Temporary crop injury may occur under abnormally hot, humid conditions. Reduce the
EXCEL SUPER (80.5g/L)	0.67 L/ha	0.27 L/ac	oil concentrate to 1 L/ha (0.4 L/ac) when these conditions occur.
plus bentazon	0.84 to 1.08 kg/ha		If broadleaf and grass weeds are not in the correct leaf stage for a tank-mix application,
BASAGRAN (480g/L)	1.75 to 2.25 L/ha	0.7 to 0.9 L/ac	use a split application at the correct stage for each product.
plus oil concentrate			
ASSIST	2 L/ha	0.8 L/ac	

TABLE 6–10.
Lima and Snap Bean Herbicide Weed Control Ratings

Note: Weed control ratings are given as 0–9, where 0 indicates no control, and 9 indicates 90–100% control under ideal conditions. Ratings are subjective values based on best available information and give general comparisons based on use as descibed in this guide. Under unfavourable conditions (e.g., too dry, too wet, too cold or poor application), the herbicides may not be as effective as indicated. Ratings may vary with weed and crop stage and with the timing and rates of the product(s) being used.

				Annual Grasses						Annual Broadleaves								Perennials						
Treatment	Trade Name	Lima beans	Snap beans	barnyard grass	crabgrass	fall panicum	foxtail	old witch grass	proso millet	buckwheat, wild	lady's-thumb	lamb's-quarters	mustards	nightshades, annual	pigweeds	ragweed	velvetleaf	bindweed, field	horsetail	milkweed	nutsedge	quackgrass	sow-thistle	thistle, Canada
Soil-applied grass herbicides																								
EPTC	EPTAM		✔	**9**	**9**	**9**	**9**	**9**	7	2	7	**7**	5	8	7	5	5	?	?	?	**8**	7	?	?
s-metolachlor	DUAL MAGNUM	✔	✔	**9**	**9**	**8/9**[a]	**9**	**9**	7	2	2	7	2	**8/9**[b]	**7/8**	2	2	0	0	0	**8/9**[c]	0	0	0
trifluralin	RIVAL, TREFLAN or BONANZA 400	✔	✔	**9**	**9**	9	**9**	9	7	**5**	2	**8**	2	2	**8**	2	2	2	2	2	2	2	2	2
Soil-applied broadleaf herbicides																								
metobromuron	PATORAN	✔	✔	**5**	**5**	5	**5**	**5**	5	**8**	**9**	**9**	**9**	7	**9**	**8**	6	2	2	2	2	2	2	2
monolinuron	AFESIN	✔	✔	**5**	**5**	5	**5**	5	5	**8**	**9**	**9**	9	7	**9**	**8**	6	2	2	2	2	2	2	2
Soil-applied grass and broadleaf herbicides																								
imazethapyr	PURSUIT		✔	8	7	7	**9**	8	**7**	8	**9**	**9**	**9**	**9**	**9**	**8**	**9**	2	2	2	2	6	2	2
Postemergent grass herbicides																								
diclofop-methyl	HOE-GRASS 284	✔	✔	**8**	**5**	**8**	**8**	**8**	3	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
fenoxaprop-p-ethyl	EXCEL SUPER		✔	**9**	**8**	**9**	**9**	**9**	**9**	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
sethoxydim	POAST ULTRA[d]	✔	✔[d]	**9**	**8**	**9**	**9**	**9**	**9**	0	0	0	0	0	0	0	0	0	0	0	0	**6**	0	0
Postemergent broadleaf herbicides																								
bentazon	BASAGRAN, BASAGRAN FORTE	✔		0	0	0	0	0	0	6	**9**	**8**	**9**	7	**7**	**8**	9	**5**	2	2	**8**	1	5	**7**
fomesafen	REFLEX		✔	0	0	0	0	0	0	8	**8**	**6**	**9**	**8**	**9**	**9**	**6**	?	?	?	?	?	?	?

? = Insufficient information available to make a rating.

Ratings in **BOLD** suggest the weed is listed on the product label for control or suppression. Please see product label for more information on registered weed species, product uses and precautions.

[a] Use the high rate of herbicide for optimum control.
[b] Use PRE timing for optimum control.
[c] Use PPI timing for optimum control.
[d] POAST ULTRA (quackgrass rate: 1.1 L/ha) is not registered for use on snap beans.

Beets (Red)

PREPLANT - See under PREPLANT - SITE PREPARATION for details of products, rates and remarks.

PREPLANT INCORPORATED - Two incorporations at right angles operating at a depth of 10 cm using a double disk (7-10 km/hour) or vibrating shank S-tine cultivator (10-13 km/hour) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness, and/or treating fields with perennial weeds last.

PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

cycloate RO-NEET (720g/L)	3.42 to 4.5 kg/ha 4.75 to 6.25 L/ha	1.9 to 2.5 L/ac	Apply in 150 to 300 L/ha (60-120 L/ac) water. Use on mineral soils only. Cycloate should be applied to a dry soil surface before planting and incorporated. Use the lower rate on sandy soils. These treatments are usually not effective on highly organic soils.
pyrazon PYRAMIN FL (430g/L)	3.54 to 4.4 kg/ha 8.25 to 10.25 L/ha	3.3 to 4.1 L/ac	Apply in 150 to 300 L/ha (60-120 L/ac) water. DO NOT use on soils less than 3% organic matter. Rainfall or irrigation is required for herbicidal activation.
pyrazon PYRAMIN FL (430g/L) plus CITOWETT PLUS SUPER SPREADER STICKER	3.54 kg/ha 8.25 L/ha	3.3 L/ac	Apply in 300-400 L/ha (120-160 L/ac) water. The use of any other oils or surfactants may cause crop injury. DO NOT use ASSIST or MERGE. For best results, apply before third true leaf or broadleaf weeds.
phenmedipham SPIN-AID (150g/L)	0.75 to 1 kg/ha 5 to 6.6 L/ha	2 to 2.64 L/ac	DO NOT apply more than twice per season. Use a maximum of 28 L of water for each litre Spin-Aid. Spin-Aid may cause temporary growth retardation and/or chlorosis or tip burn on red beets. Beets usually resume normal growth within 10 days. Apply Spin-Aid when weeds are past the cotyledonary up to the 4 true leaf stage. Spin-Aid is selective in red beets past the 3 true leaf stage. Red Beets in the cotyledonary stage may be scorched. DO NOT spray while dew is present. Rainfall within 6 hours of spraying may reduce weed kill. Delay application until evening if days are hot (30°C or over) or rapid climatic change from cool, overcast days. DO NOT apply if beets are under stress.

Cabbage, Cauliflower, Broccoli, Brussels Sprouts

PREPLANT - See under PREPLANT - SITE PREPARATION for details of products, rates and remarks.

PREPLANT INCORPORATED - Two incorporations at right angles operating at a depth of 10 cm using a double disk (7-10 km/hour) or vibrating shank S-tine cultivator (10-13 km/hour) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness, and/or treating fields with perennial weeds last.

PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

Active Ingredient TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACRE	PRECAUTIONS (For more information, see "Notes on Chemicals" section.)
Soil Applied Grass and Broadleaf Herbicides			
napropamide DEVRINOL DF (50 DF)	1.12 to 2.25 kg/ha 2.25 to 4.5 kg/ha	 0.9 to 1.8 kg/ac	Use the lower rate on light soils (coarse textured-sandy and sandy loam). One application per year as a preemergent or preplant incorporated treatment. DO NOT harvest within 60 days. Usual rotational crop restrictions apply. Apply to well worked soil that is dry enough to permit thorough incorporation to a depth of 2.5 to 5.0 cm. Incorporate the same day as applied. After harvest, soil should be worked (across rows if banded) to prevent injury to succeeding crops. Small grains seeded in the fall may be stunted but not otherwise affected. Use on transplanted cabbage, cauliflower, and broccoli only. Consult product labels for more information.
s-metolachlor DUAL MAGNUM (915g/L) or s-metolachlor/benoxacor DUAL II MAGNUM (915g/L)	1.14 to 1.6 kg/ha 1.25 to 1.75 L/ha 1.14 to 1.6 kg/ha 1.25 to 1.75 L/ha	 0.5 to 0.7 L/ac 0.5 to 0.7 L/ac	Apply within 2 days of transplanting before weeds emerge. Use the higher rate for heavier weed pressure. Apply as a ground application only in 300 L water/ha. Use only one application per year. Do not incorporate, and do not use on seeded cole crops. Do not apply to soil with less than 1% or more than 10% organic matter. Use on transplanted cabbage, cauliflower and broccoli only.
trifluralin TREFLAN (480 g/L) RIVAL DF (60 DF) BONANZA 400 (400g/L)	0.6 to 1.1 kg/ha 1.25 to 2.3 L/ha 1 to 1.9 kg/ha 1.5 to 2.75 L/ha	 0.5 to 0.92 L/ac 0.4 to 0.76 kg/ac 0.6 to 1.1 L/ac	Direct seeded cabbage or cauliflower or transplants of cabbage, cauliflower, broccoli and Brussels sprouts. Incorporate after application.
Post-emergent Grass Herbicides			
fenoxaprop-p-ethyl EXCEL SUPER (80.5g/L)	0.054 kg/ha 0.67 L/ha	 0.27 L/ac	NOT REGISTERED FOR USE ON BRUSSELS SPROUTS. Apply when majority of annual grasses are in the 1 to 6 leaf stage or until volunteer corn is up to 25 cm tall. Second flush annual grasses will not be controlled if emergence occurs after application.
fluazifop-p-butyl FUSILADE II (125g/L)	0.1 to 0.25 kg/ha 0.8 to 2 L/ha	 0.32 to 0.8 L/ac	Apply at 0.8 L/ha (0.32 L/ac) at 2-5 leaf stage of annual grasses, volunteer wheat and barley. Apply at 1 to 2 L/ha (0.4-0.8 L/ac) at 3-5 leaf stage of quackgrass and wirestem muhly. Thorough preplant tillage, fragmenting quackgrass rhizome improves control. Inter-row cultivation should not occur until 5 days after application. Make one application per season.
sethoxydim POAST ULTRA (450g/L) plus surfactant/solvent MERGE	0.15 to 0.2 kg/ha 0.32 to 0.47 L/ha 1 L/ha	 0.13 to 0.19 L/ac 0.4 L/ac	Broccoli, cabbage and cauliflower are tolerant to sethoxydim at any stage of growth. Apply sethoxydim to emerged grasses in the 1 to 6 leaf stage during active growth while crop is small enough to permit thorough spray coverage. Complete control is normally obtained 7 to 21 days after treatment. Apply using 110 to 200 L/ha (44-80 L/ac) water. DO NOT use on Brussels sprouts.
sethoxydim POAST ULTRA (450g/L) plus surfactant/solvent MERGE	0.5 kg/ha 1.1 L/ha 1 to 2 L/ha	 0.45 L/ac 0.4 to 0.8 L/ac	Thorough preplant tillage will provide more uniform quackgrass emergence. Apply at the 1 to 3 leaf stage of actively growing quackgrass in 110 to 200 L/ha (44-80 L/ac) water. Use MERGE at a rate of 1 % v/v. Crop competition and inter-row cultivation 7 to 14 days after application will provide quackgrass control for 6 to 8 weeks. Use on cabbage and cauliflower only.
Post-emergent Broadleaf Herbicides			
clopyralid LONTREL 360 (360g/L)	0.20 kg/ha 0.56 L/ha	 0.2 L/ac	Apply post transplant as a ground application only, in 300 L water/ha. Use only one application per year, no closer than 30 days to harvest. Use on transplanted cabbage, cauliflower and broccoli only.
pyridate LENTAGRAN (45 WP)	0.9 kg/ha 2 kg/ha	 0.8 kg/ac	May be applied following a ppi application of trifluralin. Use on direct-seeded or transplanted cabbage only. Apply when crop is well established. See label for further details.

Carrots

PREPLANT - See under **PREPLANT - SITE PREPARATION** for details of products, rates and remarks.

PREPLANT INCORPORATED - Two incorporations at right angles operating at a depth of 10 cm using a double disk (7-10 km/hour) or vibrating shank S-tine cultivator (10-13 km/hour) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness, and/or treating fields with perennial weeds last.

PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

trifluralin	0.6 to 1.1 kg/ha		A preplanting application of trifluralin on mineral soils can control most weeds until the carrots have developed to the stage at which the linuron postemergence treatment can be used.
TREFLAN EC (480g/L)	1.25 to 2.4 L/ha	0.5 to 0.96 L/ac	
RIVAL DF (60 DF)	1 to 1.9 kg/ha	0.4 to 0.76 kg/ac	
BONANZA 400 (400g/L)	1.5 to 2.75 L/ha	0.6 to 1.1 L/ac	
followed by			
linuron	0.55 to 1.625 kg/ha		
LOROX DF (50 DF)	1.1 to 3.25 kg/ha	0.44 to 1.3 kg/ac	
or linuron	0.624 to 1.2 kg/ha		
AFOLAN F (480g/L)	1.3 to 2.5 L/ha	0.52 to 1 L/ac	
LINURON 480 (480g/L)	1.1 to 2.25 L/ha	0.44 to 0.9 L/ac	
Preplant followed by Postemergence			
linuron	0.55 to 1.125 kg/ha		These treatments must be at least 2 weeks apart. DO NOT apply more than 2 applications per season.
LOROX DF (50 DF)	1.1 to 2.25 kg/ha	0.44 to 0.9 kg/ac	
followed by linuron	1.125 to 2.25 kg/ha		
LOROX DF (50 DF)	2.25 to 4.5 kg/ha	0.9 to 1.8 kg/ac	
OR			
linuron	0.624 to 0.912 kg/ha		
AFOLAN F (480g/L)	1.3 to 1.9 L/ha	0.52 to 0.76 L/ac	
followed by linuron	0.912 to 1.2 kg/ha		
AFOLAN F (480g/L)	1.9 to 2.5 L/ha	0.76 to 1 L/ac	
OR			
linuron	0.53 to 1.08 kg/ha		
LINURON 480 (480g/L)	1.1 to 2.25 L/ha	0.44 to 0.9 L/ac	
followed by linuron	1.08 to 2.165 kg/ha		
LINURON 480 (480g/L)	2.25 to 4.5 L/ha	0.9 to 1.8 L/ac	
prometryne	1.8 to 3.4 kg/ha		A combination procedure which has been successful on muck soils is to use the preemergence prometryne treatment followed by a postemergence linuron treatment as required.
GESAGARD 480 SC (480g/L)	3.75 to 7.08 L/ha	1.5 to 2.83 L/ac	
followed by linuron	0.55 to 1.625 kg/ha		
LOROX DF (50 DF)	1.1 to 3.25 kg/ha	0.44 to 1.3 kg/ac	
or linuron	0.624 to 1.2 kg/ha		
AFOLAN F (480g/L)	1.3 to 2.5 L/ha	0.52 to 1 L/ac	

Active Ingredient TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACRE	PRECAUTIONS (For more information, see 'Notes on Chemicals' section.)
linuron LOROX DF (50 DF) or linuron AFOLAN F (480g/L)	0.55 to 1.625 kg/ha 1.1 to 3.25 kg/ha 0.624 to 1.2 kg/ha 1.3 to 2.5 L/ha	 0.44 to 1.3 kg/ac 0.52 to 1 L/ac	Apply in 200 to 350 L/ha (80-140 L/ac) water. Apply as a band or broadcast spray after planting but before carrots emerge. Use the lower rate on sandy soils. Carrots are very sensitive to this treatment at the time of emergence and severe injury can occur at this time if there is a heavy rain or if the area is irrigated.
prometryne GESAGARD 480 SC (480g/L)	1.8 to 3.4 kg/ha 3.75 to 7.08 L/ha	 1.5 to 2.83 L/ac	Apply in 200 to 1000 L/ha (80-400 L/ac) water. Use the lower rate on sandy soils and the higher rate on muck soils. Prometryne should also be applied soon after seeding. DO NOT use at or near time of emergence. IT IS NOT REGISTERED FOR POSTEMERGENCE USE.
trifluralin TREFLAN EC (480g/L) RIVAL DF (60 DF) BONANZA 400 (400g/L)	0.6 to 1.1 kg/ha 1.25 to 2.4 L/ha 1 to 1.9 kg/ha 1.5 to 2.75 L/ha	 0.5 to 0.96 L/ac 0.4 to 0.76 kg/ac 0.6 to 1.1 L/ac	Incorporate after application.
diclofop-methyl HOE-GRASS 284 (284g/L)	1 kg/ha 3.5 L/ha	 1.4 L/ac	Diclofop-methyl should be applied postemergence to annual grasses in the 1 to 4 leaf stage (optimum control at 2 to 3 leaf stage, approximately 10 to 16 days after emergence). DO NOT apply if rain is expected within one hour after application.
fenoxaprop-p-ethyl EXCEL SUPER (80.5g/L)	0.054 kg/ha 0.67 L/ha	 0.27 L/ac	Apply when majority of annual grasses are in the 1 to 6 leaf stage or until volunteer corn is up to 25 cm tall. Second flush annual grasses will not be controlled if emergence occurs after application. DO NOT apply if rain is expected within one hour after application.
fluazifop-p-butyl FUSILADE II (125g/L)	0.075 to 0.25 kg/ha 0.6 to 2 L/ha	 0.24 to 0.8 L/ac	Apply when crop is 10 cm in height or less. Apply at 0.6-1 L/ha (0.24-0.4 L/ac) at 2-5 leaf stage of annual grasses. Apply at 0.8 L/ha (0.32 L/ac) at 2-5 leaf stage of volunteer wheat and barley. Apply at 1-2 L/ha (0.4-0.8 L/ac) at 3-5 leaf stage of quackgrass and wire stemmed muhly. Thorough preplant tillage fragmenting quackgrass rhizomes improves control. Inter-row cultivation should not occur until 5 days after application. Apply other postemergence herbicides separately at least 3 days after FUSILADE II.
linuron LOROX DF (50 DF) or linuron AFOLAN F (480g/L)	1.125 to 2.25 kg/ha 2.25 to 4.5 kg/ha 0.912 to 2.256 kg/ha 1.9 to 4.69 L/ha	 0.9 to 1.8 kg/ac 0.76 to 1.88 L/ac	Spray when crop has 2 or more fully developed leaves (8-15 cm tall). Carrot leaves will become yellow or light green, but they will soon regain their normal colour. Injury may occur when spraying is done during hot, dry weather (>32°C) or when crop is under stress. Apply before annual grasses are 5 cm high and before broadleaf weeds are 15 cm high.
mineral oil (herbicidal) overall spray rows only undiluted	 600 to 800 L/ha 300 to 400 L/ha	 240 to 320 L/ac 120 to 160 L/ac	Apply the selective herbicidal oil as soon as true leaves develop and before roots of carrots are thicker than a pencil. Later treatments may produce an oil flavor. Weeds should be less than 10 cm high. Ragweed, wormwood, and wild carrot are not controlled.
Celery			
PREPLANT - See under PREPLANT - SITE PREPARATION for details of products, rates and remarks.			

linuron AFOLAN F (480g/L)	0.9 to 2.25 kg/ha 1.87 to 4.68 L/ha	 0.75 to 1.87 L/ac	Apply in 150 to 300 L/ha (60-120 L/ac) water in the transplanted crop. Linuron should be applied 8 to 10 days after transplanting. Some yellowing of the leaves may be noticed but this will be temporary.
mineral oil (herbicidal) overall spray rows only	 600 to 800 L/ha 300 to 400 L/ha	 240 to 320 L/ac 120 to 160 L/ac	Herbicidal oil should be used only on outdoor seedbed and only if the soil is moist. Apply as the true leaves develop on the celery, before weeds are 10 cm high.
prometryne GESAGARD 480 SC (480g/L)	1.8 to 2.2 kg/ha 3.75 to 4.58 L/ha	 1.5 to 1.83 L/ac	Apply in 200 to 1000 L/ha (80-400 L/ac) water in the transplanted crop. DO NOT use on direct seeded crop. Prometryne applications should be delayed 21 days after transplanting crop until the celery plants are established.

Cucumber

PREPLANT - See under PREPLANT - SITE PREPARATION for details of products, rates and remarks.

PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

glyphosate ROUNDUP (356g/L) or glyphosate TMS TOUCHDOWN 480 (330g/L) plus surfactant AGRAL 90, AG-SURF, ENHANCE	0.267 to 1.246 kg/ha 0.75 to 3.5 L/ha 0.248 to 1.155 kg/ha 0.75 to 3.5 L/ha 0.35 L/ha	 0.3 to 1.4 L/ac 0.3 to 1.4 L/ac 0.14 L/ac	Till and fertilize soil in early spring. Allow weeds to grow. Spray weeds just before seeding crop. Use low rate for small weeds (8 cm), medium rates for weeds 8 to 15 cm and higher rate for weeds over 15 cm tall. Apply recommended preemergence or postemergence herbicides to control new flushes of weeds or use mechanical means of control.
bensulide PREFAR (480g/L)	5.75 to 6.75 kg/ha 12 to 14 L/ha	 4.8 to 5.6 L/ac	Apply preplant incorporated on mineral soils only. Bensulide should be applied before planting and incorporated thoroughly into the soil to a depth of 2.5 to 5 cm.
naptalam ALANAP (240g/L)	2.64 to 7.19 kg/ha 11 to 30 L/ha	 4.4 to 12 L/ac	Apply preemergent to weeds, following seeding of cucumber crop. ALANAP may also be applied as a postemergence spray about one month after the preemergence spray when the crop has emerged following a clean cultivation.
bensulide PREFAR (480g/L) followed by naptalam ALANAP (240g/L)	4.56 to 6.75 kg/ha 9.5 to 14 L/ha 2.28 to 4.56 kg/ha 9.5 to 19 L/ha	 3.8 to 5.6 L/ac 3.8 to 7.7 L/ac	Bensulide should be applied before planting and incorporated thoroughly into the soil to a depth of 2.5 to 5 cm. DO NOT use on muck soils. Bensulide and naptalam may also be tank mixed and applied preplant incorporated. When tank mixed with naptalam, incorporation should be done to a depth of 2.5 cm or less. Use power-driven rotary cultivators or other equipment which will result in satisfactory incorporation. Use the lower rates on light, sandy soils.

Active Ingredient ▲ TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACRE	PRECAUTIONS (For more information, see "Notes on Chemicals" section.)
fluazifop-p-butyl FUSILADE II (125g/L)	0.1 to 0.25 kg/ha 0.8 to 2 L/ha	0.32 to 0.8 L/ac	Apply at 0.8 L/ha (0.32 L/ac) at 2-5 leaf stage of annual grasses, volunteer wheat and barley. Apply at 1 to 2 L/ha (0.4-0.8 L/ac) at 3-5 leaf stage of quackgrass and wirestem muhly. Thorough preplant tillage, fragmenting quackgrass rhizome improves control. Inter-row cultivation should not occur until 5 days after application. Make one application per season.
sethoxydim POAST ULTRA (450g/L) plus surfactant/solvent MERGE	0.15 to 0.2 kg/ha 0.32 to 0.47 L/ha 1 L/ha	0.13 to 0.19 L/ac 0.4 L/ac	Cucumbers are tolerant to sethoxydim at any stage of growth. Apply sethoxydim to emerged grasses in the 1 to 6 leaf stage during active growth while crop is small enough to permit thorough spray coverage. Complete control is normally obtained 7 to 21 days after treatment. Apply using 110 to 200 L/ha (44-80 L/ac) water.
sethoxydim POAST ULTRA (450g/L) plus surfactant/solvent MERGE	0.5 kg/ha 1.1 L/ha 1 to 2 L/ha	0.45 L/ac 0.4 to 0.8 L/ac	Thorough preplant tillage will provide more uniform quackgrass emergence. Apply at the 1 to 3 leaf stage of actively growing quackgrass in 110 to 200 L/ha (44-80 L/ac) water. Use MERGE at a rate of 1 % v/v. Crop competition and inter-row cultivation 7 to 14 days after application will provide quackgrass control for 6 to 8 weeks.
Garlic			
PREPLANT - See under PREPLANT - SITE PREPARATION for details of products, rates and remarks.			
PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.			
napropamide DEVRINOL DF (50 DF)	1.12 to 2.25 kg/ha 2.25 to 4.5 kg/ha	0.9 to 1.8 kg/ac	Use the lower rate on light soils (coarse textured-sandy and sandy loam). One preemergent application per year only. Apply prior to crop and weed emergence. DO NOT harvest within 60 days. Usual rotational crop restrictions apply. After harvest, soil should be worked (across rows if banded) to prevent injury to succeeding crops. Small grains seeded in the fall may be stunted but not otherwise affected. Consult product label for more information.
sethoxydim POAST ULTRA (450g/L) plus surfactant/solvent MERGE	0.15 to 0.2 kg/ha 0.32 to 0.47 L/ha 1 L/ha	0.13 to 0.19 L/ac 0.4 L/ac	Apply sethoxydim to emerged grasses in the 1 to 6 leaf stage during active growth while the crop is small enough to permit thorough spray coverage. Complete control is normally obtained 7 to 21 days after treatment. Apply using 110 L/ha (44 L/ac) water.
sethoxydim POAST ULTRA (450g/L) plus surfactant/solvent MERGE	0.5 kg/ha 1.1 L/ha 1 to 2 L/ha	0.45 L/ac 0.4 to 0.8 L/ac	Thorough preplant tillage will provide more uniform quackgrass emergence. Apply at the 1 to 3 leaf stage of actively growing quackgrass. Apply in 110 to 200 L/ha (44-80 L/ac) water. Use MERGE at a rate of 1% v/v. Crop competition inter-row cultivation 7 to 14 days after application will provide quackgrass control for 6 to 8 weeks.
bromoxynil PARDNER (280g/L)	0.28 kg/ha 1 L/ha	0.4 L/ac	Controls most annual broadleaf weeds, including triazine resistant species at the 1 to 4 leaf stage. Bromoxynil is a contact herbicide and is non-volatile. Consult product label for list of weeds controlled.
Herbs			
PREPLANT - See under PREPLANT - SITE PREPARATION for details of products, rates and remarks.			

PREPLANT INCORPORATED - Two incorporations at right angles operating at a depth of 10 cm using a double disk (7-10 km/hour) or vibrating shank S-tine cultivator (10-13 km/hour) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness, and/or treating fields with perennial weeds last.

PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

napropamide DEVRINOL DF (50 DF)	0.56 to 1.12 kg/ha 1.12 to 2.24 kg/ha	0.45 to 0.9 kg/ac	Apply in 200-900 L/ha (80-360 L/ac) water. One application per year as a preemergence or preplant incorporated treatment. Usual rotational crop restrictions apply. To avoid injury to crops not specified on the complete label, do not plant until 12 months after the last application. CAUTION: Use of DEVRINOL 50 DF at the high label rates of application may result in temporary crop stunting or retardation. However, crops will outgrow the injury and yield is unaffected. (Consult label). USE ON BASIL ONLY.
sethoxydim POAST ULTRA (450g/L) plus surfactant/solvent MERGE	0.15 to 0.2 kg/ha 0.32 to 0.47 L/ha 1 L/ha	0.13 to 0.19 L/ac 0.4 L/ac	Apply sethoxydim to emerged grasses in the 1 to 6 leaf stage during active growth while crop is small enough to permit thorough spray coverage. Complete control is normally obtained 7 to 21 days after treatment. Apply using 110-200 L/ha (44-80 L/ac) water volume. (Consult Label). USE ON SPEARMINT AND PEPPERMINT ONLY.

Leeks

PREPLANT - See under PREPLANT - SITE PREPARATION for details of products, rates and remarks.

PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

prometryne GESAGARD 480 SC (480g/L)	1.8 kg/ha 3.75 L/ha	1.5 L/ac	Apply 2 applications 10 days apart, before weeds are 5 cm high. Make the first application to well-established transplanted leeks that have produced one new fully expanded leaf. Can be used on either muck or mineral soils. DO NOT apply more than 2 applications a year. Temporary injury can occur to the lower leaves in some cultivars of leek.

Lettuce

PREPLANT - See under PREPLANT - SITE PREPARATION for details of products, rates and remarks.

PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

chlorpropham CIPC EC (480g/L)	4.5 to 6.75 kg/ha 9.36 to 14 L/ha	3.74 to 5.6 L/ac	When overhead irrigation is used at seeding time, delay chlorpropham application until after first irrigation but before crop emergence. Use lower rates in cool, wet weather to avoid injury and delay in emergence. Use lower rates in mineral soils.

Active Ingredient TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACRE	PRECAUTIONS (For more information, see "Notes on Chemicals" section.)
propyzamide KERB (50 WP)	2.2 to 4.5 kg/ha 4.4 to 9 kg/ha	1.76 to 3.6 kg/ac	Use only once per year. Apply 7-10 days post-transplant or ppi, preemergence or postemergence on seeded lettuce (55 days to harvest). Not recommended for muck soils.

Muskmelon, Watermelon, Squash and Pumpkin

PREPLANT - See under **PREPLANT - SITE PREPARATION** for details of products, rates and remarks.

PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

naptalam ALANAP (240g/L)	2.638 to 7.194 kg/ha 11 to 30 L/ha	4.4 to 12 L/ac	DO NOT USE ON BUTTERNUT SQUASH; some injury may occur to Table Queen squash. Apply prior to crop and weed emergence. ALANAP may be applied to melons (not squash or pumpkins) as a postemergence spray about 1 month after the preemergence spray when the crop has emerged but before the weeds are up.
napropamide DEVRINOL DF (50 DF)	1.12 to 2.25 kg/ha 2.24 to 4.5 kg/ha	0.9 to 1.8 kg/ac	Apply in 200-900 L/ha (80-360 L/ac) water. Make only one preemergence application per season. Use the lower rate on light soils (coarse textured, sandy or sandy loam). Shepherd's-purse and lady's thumb may escape treatment at this rate. DEVRINOL requires rainfall or irrigation with sufficient water to wet the soil to a depth of 5 to 10 cm soon after application for adequate weed control. Application should be timed to take advantage of rainfall if irrigation is not available. After harvest, soil should be worked (across rows if banded) to prevent injury to succeeding crops. Small grains seeded in the fall may be stunted but not otherwise affected. Consult product labels for more information. USE ON DIRECT SEEDED PUMPKIN AND SQUASH ONLY.
sethoxydim POAST ULTRA (450g/L) plus surfactant/solvent MERGE	0.15 to 0.2 kg/ha 0.32 to 0.47 L/ha 1 to 2 L/ha	0.13 to 0.19 L/ac 0.4 to 0.8 L/ac	Pumpkins and Squash ONLY - Apply the lower rate for actively growing annual grasses in the 1 to 6-leaf stage. DO NOT apply closer than 30 days to harvest.
sethoxydim POAST ULTRA (450g/L) plus surfactant/solvent MERGE	0.5 kg/ha 1.1 L/ha 1 to 2 L/ha	0.45 L/ac 0.4 to 0.8 L/ac	Pumpkins and Squash only. Thorough preplant tillage will provide more uniform quackgrass emergence. Apply at the 1 to 3 leaf stage of actively growing quackgrass in 110 to 200 L/ha (44-80 L/ac) water. Use MERGE at a rate of 1% v/v. Crop competition and inter-row cultivation 7 to 14 days after application will provide quackgrass control for 6 to 8 weeks.

Onions

Most experience with herbicides below has been with the seeded crop. Experience with sets and limited experience with Spanish onions have been satisfactory. On green bunching onions, the granular formulations (applied when the leaves are dry) are recommended to avoid leaf injury.

PREPLANT - See under **PREPLANT - SITE PREPARATION** for details of products, rates and remarks.

PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

chlorpropham CIPC EC (480g/L) CIPC GR (20 Gr)	4.5 to 9 kg/ha 9.36 to 18.72 L/ha 22.5 to 45 kg/ha	 3.74 to 7.49 L/ac 9 to 18 kg/ac	Apply these rates on muck soils. Use 9.36-14 L/ha (3.74-5.6 L/ac) on mineral soils. Preemergence or directed postemergence. Chlorpropham is most effective when the weed seeds are germinating. Under cool, moist conditions reduction in stand with decrease in yields has occurred. Direct the postemergence spray to avoid onion leaves. Excellent control of purslane may be obtained. Groundsel, lamb's-quarters and ragweed are somewhat resistant. DO NOT use this chemical on bunching onions.
GRASSES			
clethodim SELECT (240g/L)	0.09 kg/ha 0.38 L/ha	 0.15 L/ac	For control of annual blue grass, other annual grasses and quackgrass. Apply when the crop is in the 1-4 leaf stage and the weeds are in the 2-6 leaf stage.
diclofop-methyl HOE-GRASS 284 (284g/L)	1 kg/ha 3.5 L/ha	 1.4 L/ac	Diclofop-methyl should be applied postemergence to annual grasses in the 1 to 4 leaf stage (optimum control at 2 to 3 leaf stage, approximately 10 to 16 days after emergence). DO NOT apply if rain is expected within one hour after application.
fenoxaprop-p-ethyl EXCEL SUPER (80.5g/L)	0.054 kg/ha 0.67 L/ha	 0.27 L/ac	Apply when majority of annual grasses are in the 1 to 6 leaf stage or until volunteer corn is up to 25 cm tall. Second flush annual grasses will not be controlled if emergence occurs after application. DO NOT apply if rain is expected within one hour after application.
fluazifop-p-butyl FUSILADE II (125g/L)	0.075 to 0.125 kg/ha 0.6 to 1 L/ha	 0.24 to 0.4 L/ac	Volunteer cereals will be controlled with 0.8 L/ha (0.32 L/ac). A repeat application may be made to control annual grasses, if required, but not less than 42 days before harvest. Apply in a maximum volume of 300 L/ha (120 L/ac). See "Notes on Chemicals" section.
fluazifop-p-butyl FUSILADE II (125g/L)	0.125 to 0.25 kg/ha 1 to 2 L/ha	 0.4 to 0.8 L/ac	Use the higher rate when quackgrass is present. Preplant tillage to break up rhizomes will improve control of quackgrass. Deep plowing may hinder the break up of rhizomes. Apply in a maximum volume of 300 L/ha (120 L/ac). Only one application of this rate is permitted per season and it should be no less than 60 days to harvest. See "Notes on Chemicals" section.
sethoxydim POAST ULTRA (450g/L) plus surfactant/solvent MERGE	0.15 to 0.2 kg/ha 0.32 to 0.47 L/ha 1 L/ha	 0.13 to 0.19 L/ac 0.4 L/ac	Apply sethoxydim to emerged grasses in the 1 to 6 leaf stage during active growth while the crop is small enough to permit thorough spray coverage. Complete control is normally obtained 7 to 21 days after treatment. Apply using 110 L/ha (44 L/ac) water.
sethoxydim POAST ULTRA (450g/L) plus surfactant/solvent MERGE or oil concentrate ASSIST	0.5 kg/ha 1.1 L/ha 1 to 2 L/ha 4 L/ha	 0.45 L/ac 0.4 to 0.8 L/ac 1.6 L/ac	Thorough preplant tillage will provide more uniform quackgrass emergence. Apply at the 1 to 3 leaf stage of actively growing quackgrass. Apply in 110-200 L/ha (44-80 L/ac) water. Use MERGE at a rate of 1% v/v. Crop competition inter-row cultivation 7 to 14 days after application will provide quackgrass control for 6 to 8 weeks.
ONIONS			
oxyfluorfen GOAL 2XL (240g/L)	0.12 kg/ha 0.5 L/ha	 0.2 L/ac	Apply in minimum of 500 L/ha (200 L/ac) water at the 2 fully developed leaf stage of onions. DO NOT apply in excess of 2.0 L/ha (0.8 L/ac) per year. PERMITS are required from the Ontario Ministry of the Environment under the Pesticides Act for the use of GOAL 2XL (oxyfluorfen). Permit applications should be made to the Ministry of Environment Pesticide Control Field Officers.

Active Ingredient TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACRE	PRECAUTIONS (For more information, see "Notes on Chemicals" section.)
pendimethalin PROWL 400 (400g/L)	1 to 1.5 kg/ha 2.5 to 3.75 L/ha	 1 to 1.5 L/ac	Mineral soils: Pendimethalin can be applied at the 2 leaf stage and 6 leaf stage of crop development. Both applications are required for season long control. Pendimethalin controls weeds as they emerge. Destroy existing weeds prior to application. For use on direct seeded dry bulb onions grown in mineral soils.
pendimethalin PROWL 400 (400g/L)	3 kg/ha 7.5 L/ha	 3 L/ac	Muck soils: Pendimethalin can be applied at the loop and/or 2 leaf stage of crop development. Both applications are required for season long control. Pendimethalin controls weeds as they emerge. Destroy existing weeds prior to application. For use on direct seeded dry bulb onions grown in muck soil only.

Parsnips

PREPLANT - See under **PREPLANT - SITE PREPARATION** for details of products, rates and remarks.

PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

Preemergent Control of Broadleaf Weeds

linuron AFOLAN F (480g/L) followed by linuron AFOLAN F (480g/L)	0.624 to 0.912 kg/ha 1.3 to 1.9 L/ha 0.912 to 1.2 kg/ha 1.9 to 2.5 L/ha	 0.5 to 0.75 L/ac 0.75 to 1 L/ac	These treatments must be at least 2 weeks apart. DO NOT apply more than these two applications per season.

Soil Applied Grass and Broadleaf Herbicides

chlorpropham CIPC EC (480g/L) CIPC (20 Gr)	4.5 to 9 kg/ha 9.36 to 18.72 L/ha 22.5 to 45 kg/ha	 3.75 to 7.5 L/ac 9 to 18 kg/ac	Chlorpropham should be used at the lower rate on mineral soils and at the higher rate on muck. Apply at time of seeding or until shortly before emergence of crop and weeds.
linuron AFOLAN F (480g/L)	0.624 to 1.2 kg/ha 1.3 to 2.5 L/ha	 0.5 to 1 L/ac	Apply in 200-400 L/ha (80-160 L/ac) water. Linuron should be applied soon after seeding. Use lower rate on sandy soil. Heavy rains or irrigation at time of emergence may cause injury.

Postemergent Grass and Broadleaf Herbicides

linuron AFOLAN F (480g/L)	0.912 to 2.256 kg/ha 1.9 to 4.7 L/ha	 0.76 to 1.88 L/ac	Apply after parsnips are 8 cm tall. On sandy soils, do not use more than 2.5 L/ha (1 L/ac). Applications when the temperature is high, may cause injury especially at the higher rate.
mineral oil (herbicidal) overall spray row only undiluted	 600 to 800 L/ha 300 to 400 L/ha	 240 to 320 L/ac 120 to 160 L/ac	Herbicidal oil should be applied as soon as true leaves develop and before roots of parsnips are thicker than a pencil. Later treatments may produce an oil flavor. Weeds should be less than 10 cm high.

Peas

PREPLANT - See under **PREPLANT - SITE PREPARATION** for details of products, rates and remarks.

PREPLANT INCORPORATED - Two incorporations at right angles operating at a depth of 10 cm using a double disk (7-10 km/hour) or vibrating shank S-tine cultivator (10-13 km/hour) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness, and/or treating fields with perennial weeds last.

PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

s-metolachlor DUAL MAGNUM (915g/L)	1.14 to 1.6 kg/ha 1.25 to 1.75 L/ha	 0.5 to 0.7 L/ac	Make one application per season before weeds emerge. Apply in 150-250 L/ha (60-100 L/ac) water. Apply by ground application equipment only. Use higher rate for heavier weed problems.
triallate AVADEX BW (400g/L)	1.7 kg/ha 4.25 L/ha	 1.7 L/ac	Apply and incorporate before planting in 150-200 L/ha (60-80 L/ac) water, for dry peas only.
prometryne GESAGARD 480 (480 g/L)	1.8 to 2.2 kg/ha 3.75 to 4.58 L/ha	 1.5 to 1.83 L/ac	Apply before weeds emerge in 200-1000 L/ha (80-400 L/ac) water. Will control Eastern Black Nightshade.
imazethapyr PURSUIT (240g/L)	0.075 kg/ha 0.312 L/ha	 0.125 L/ac	Only apply once per year as a preplant incorporated or preemergence treatment. Apply in 200 L/ha (80 L/ac) water. Allow a preharvest interval of 60 days.
trifluralin TREFLAN(480g/L) RIVAL DF (60 DF) BONANZA 400 (400g/L)	0.6 to 0.8 kg/ha 1.25 to 1.66 L/ha 1 to 1.3 kg/ha 1.5 to 2 L/ha	 0.5 to 0.66 L/ac 0.4 to 0.52 kg/ac 0.6 to 0.8 L/ac	Incorporate after application.
diclofop-methyl HOE-GRASS 284 (284g/L)	0.7 kg/ha 2.5 L/ha	 1 L/ac	For optimum weed control apply diclofop-methyl when the majority of the grass weeds are in the 2 to 3 leaf stage. Spray tips angled forward at 45° will give better coverage. DO NOT apply if rain is expected within one hour after application.
fenoxaprop-p-ethyl EXCEL SUPER (80.5g/L)	0.054 kg/ha 0.67 L/ha	 0.27 L/ac	Apply when majority of annual grasses are in the 1 to 6 leaf stage or until volunteer corn is up to 25 cm tall. Second flush annual grasses will not be controlled if emergence occurred after application. DO NOT graze treated fields prior to harvest.
sethoxydim POAST ULTRA (450g/L) plus oil concentrate ASSIST or surfactant/solvent MERGE	0.15 to 0.2 kg/ha 0.32 to 0.47 L/ha 2 L/ha 1 L/ha	 0.13 to 0.19 L/ac 0.8 L/ac 0.4 L/ac	Apply sethoxydim to emerged grasses in the 1 to 6 leaf stage during active growth while the crop is small enough to permit thorough spray coverage. Complete control is normally obtained 7 to 21 days after treatment. Apply using 110-200 L/ha (44-80 L/ac) water.
sethoxydim POAST ULTRA (450g/L) plus oil concentrate ASSIST or surfactant/solvent MERGE	0.5 kg/ha 1.1 L/ha 4 L/ha 1 to 2 L/ha	 0.45 L/ac 1.6 L/ac 0.4 to 0.8 L/ac	Thorough preplant tillage will provide more uniform quackgrass emergence. Apply at the 1-3 leaf stage of actively growing quackgrass. Apply in 110-200 L/ha (44-80 L/ac) water. Use MERGE at a rate of 1% v/v. Crop competition and inter-row cultivation 7 to 14 days after application will provide quackgrass control for 6 to 8 weeks.

Active Ingredient TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACRE	PRECAUTIONS (For more information, see "Notes on Chemicals" section.)
Peas			
bentazon BASAGRAN (480g/L) plus surfactant CITOWETT PLUS or SUPER SPREADER STICKER or oil concentrate ASSIST	0.84 to 1.08 kg/ha 1.75 to 2.25 L/ha 2.5 L/1000L water 1.25 to 2.5 L/1000L 1 to 2 L/ha	 0.7 to 0.9 L/ac 2.5 L/1000L water 1.25 to 2.5 L/1000L 0.4 to 0.8 L/ac	Apply in 100-400 L/ha (40-160 L/ac) water postemergence after the peas have 3 pairs of leaves. Top growth of nutsedge and Canada thistle are controlled and field bindweed may be suppressed by 2 applications of 1.75 L/ha (0.7 L/ac); 10 days apart may be required. Under hot, humid conditions, reduce ASSIST oil concentrate to 1 L/ha (0.4 L/ac).
MCPA MCPA SODIUM 300 (300g/L) or MCPA MCPA AMINE (500g/L)	0.38 kg/ha 1.25 L/ha 0.25 kg/ha 0.5 L/ha	 0.5 L/ac 0.2 L/ac	Apply in 100 to 200 L/ha (40-80 L/ac) water. Avoid conditions prone to spray drift; high temperatures, high humidity, windy.
MCPB/MCPA TROPOTOX PLUS (400g/L) CLOVITOX PLUS (400 g/L)	1.1 to 1.7 kg/ha 2.75 to 4.25 L/ha 2.75 to 4.25 L/ha	 1.1 to 1.7 L/ac 1.1 to 1.7 L/ac	Apply in 150 to 200 L/ha (60-80 L/ac) water when the peas have 3 to 6 expanded leaves. DO NOT apply over 27 C, or under drought conditions.

Peppers

All treatments should be applied in 150 to 300 L/ha (60-120 L/ac) water.

Discussion of cultural methods can be found in the tomato section.

Weed control in the pepper crop is accomplished best by combining chemical and cultural methods.

PREPLANT - See under PREPLANT - SITE PREPARATION for details of products, rates and remarks.

PREPLANT INCORPORATED - Two incorporations at right angles operating at a depth of 10 cm using a double disk (7-10 km/hour) or vibrating shank S-tine cultivator (10-13 km/hour) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness, and/or treating fields with perennial weeds last.

Soil Applied Grass and Broadleaf Herbicides			
napropamide DEVRINOL DF (50 DF)	1.12 to 2.25 kg/ha 2.25 to 4.5 kg/ha	 0.9 to 1.8 kg/ac	Apply to well worked soil that is dry enough to permit thorough incorporation to a depth of 2.5 to 5.0 cm. Incorporate day of application to avoid breakdown by sunlight. Use only one application per season. Damage to subsequent cover crops can be reduced by tillage across the rows after harvest.
trifluralin TREFLAN (480g/L) RIVAL DF (60 DF) BONANZA 400 (400g/L)	0.6 to 1.155 kg/ha 1.25 to 2.4 L/ha 1 to 1.9 kg/ha 1.5 to 2.75 L/ha	 0.5 to 0.96 L/ac 0.4 to 0.76 kg/ac 0.6 to 1.1 L/ac	Incorporate twice in cross directions using a tandem disc (7-10 km/hr) or vibrating tine cultivator (10-13 km/hr) set to work 8-10 cm deep. The first incorporation should be done as soon as possible after application but may be delayed up to 8 to 24 hours. (see label). The second incorporation is recommended anytime before planting. See "Notes on Chemicals" section for further details. If shallow cultivation is to be used to control additional broadleaf weeds, cultivation should start when the weeds have reached the 3 to 4 leaf stage.

Potatoes

A combination of chemical weed control with cultivation provides the best weed management system. Cultivation prior to potato emergence using various kinds of cultivation equipment (light harrows, finger weeders, hillers, etc.) will control the early flush of weeds. Root pruning of the crop should be minimized. If the crop is hilled after application of herbicides, it must be

realized that areas of untreated soil will surface where another flush of weeds may result.

POTATO VINE KILLING - For information on products and rates of application of vine killing, consult your Horticultural Crop Advisor and follow the product label.

PREPLANT - See under PREPLANT - SITE PREPARATION for details of products, rates and remarks.

PREPLANT INCORPORATED - Two incorporations at right angles operating at a depth of 10 cm using a double disk (7-10 km/hour) or vibrating shank S-tine cultivator (10-13 km/hour) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness, and/or treating fields with perennial weeds last.

PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

EPTC EPTAM (800g/L)	3.4 to 6.8 kg/ha 4.25 to 8.5 L/ha	 1.7 to 3.4 L/ac	Apply EPTC to a dry soil surface before planting and incorporate immediately. When applied under wet soil conditions weed control is poor. Use 2.2 to 3.4 L/ac rates for heavy weed infestations and nutsedge control. EPTAM can also be incorporated immediately at next to the last or last cultivation. This treatment may be of value if an earlier treatment has failed or if late germinating grasses are a problem. Use at 1.7 to 2.2 L/ac.
s-metolachlor DUAL MAGNUM (915g/L)	1.14 to 1.6 kg/ha 1.25 to 1.75 L/ha	 0.5 to 0.7 L/ac	DO NOT use s-metolachlor on the variety Superior, or on sandy or coarse textured soils low in organic matter. DO NOT apply DUAL MAGNUM at ground crack or if potatoes have emerged. Incorporate for nutsedge control.
linuron LOROX DF (50 DF) AFOLAN F (480g/L) LINURON 480 (480g/L)	1.1 to 2.25 kg/ha 2.2 to 4.5 kg/ha 2.3 to 4.7 L/ha 2.3 to 4.7 L/ha	 0.88 to 1.8 kg/ac 0.92 to 1.88 L/ac 0.92 to 1.88 L/ac	Linuron can be applied immediately after hilling but the potato tops must be covered with soil or the potato plants will be injured. Use the lower rate on light sandy soils and the higher rate on muck or clay soils.
metobromuron PATORAN FL (400g/L)	1 to 3.4 kg/ha 2.5 to 8.5 L/ha	 1 to 3.4 L/ac	Metobromuron may be applied immediately after planting or hilling provided the tops are covered with soil during application. Application may be made when weeds have emerged provided they do not exceed 2.5 cm and tops are not exposed. Use the lower rate on light sandy soil and the higher rates on clay and muck soils. PATORAN FL (400 g/L) at the 2.5 L/ha (1 L/ac) rate may allow certain annual weeds to escape. Inter-row cultivation may be necessary for full season control.
metribuzin SENCOR 500 F (500g/L) or metribuzin LEXONE DF (75 DF)	0.6 to 1.1 kg/ha 1.2 to 2.2 L/ha 0.481 to 1.053 kg/ha 0.64 to 1.4 kg/ha	 0.48 to 0.88 L/ac 0.25 to 0.56 kg/ac	Apply after hilling before emergence of crop or weeds. DO NOT USE ON MUCK SOILS. Use the lower rate on sandy soil. DO NOT use on Belleisle, Tobique, or red skinned varieties. Metribuzin may be applied as pre/post split application provided the maximum total application rate does NOT exceed 1.12 kg active/ha. DO NOT use metribuzin postemergence on red skinned varieties.
metribuzin SENCOR 75 DF (75 WG) plus linuron LINURON 480 (480g/L)	0.63 to 0.825 kg/ha 0.84 to 1.1 kg/ha 0.72 to 1.728 kg/ha 1.5 to 3.59 L/ha	 0.34 to 0.44 kg/ac 0.6 to 1.44 L/ac	Apply after hilling and before emergence of the crop. Emerged weeds should not be taller than 4 cm. DO NOT use on muck soils. Use a lower rate on sandy soil. Use a higher rate on late potatoes for season long control. DO NOT use on Belleisle, Tobique, or red skinned varieties.
monolinuron AFESIN (200g/L)	1.1 to 2.2 kg/ha 5.5 to 11 L/ha	 2.2 to 4.4 L/ac	Monolinuron can be applied immediately after hilling but all the potato tops must be covered with soil or the crop will be injured. Use the lower rate on soils low in organic matter and the higher rate on clay or soils high in organic matter.

Active Ingredient TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACRE	PRECAUTIONS (For more information, see "Notes on Chemicals" section.)
Soil Applied Grass and Broadleaf Herbicides			
EPTC EPTAM (800g/L) plus metribuzin SENCOR 500 F (500g/L) or metribuzin LEXONE DF (75 DF)	3.4 to 4.4 kg/ha 4.25 to 5.5 L/ha 0.55 to 0.875 kg/ha 1.1 to 1.75 L/ha 0.624 to 0.902 kg/ha 0.83 to 1.2 kg/ha	 1.7 to 2.2 L/ac 0.44 to 0.7 L/ac 0.33 to 0.48 kg/ac	Apply as a tank mix in 220-330 L/ha (88-132 L/ac) water and incorporate immediately. DO NOT use on muck soils. DO NOT use on Belleisle or Tobique varieties. May be applied through the irrigation system.
glufosinate ammonium IGNITE (150g/L)	0.405 to 0.75 kg/ha 2.7 to 5 L/ha	 1.08 to 2 L/ac	Apply in 110-330 L/ha (44-132 L/ac) of water at no later than ground crack of the crop. Weeds which have not emerged will not be controlled. Ensure uniform coverage. See label for more detailed information.
glufosinate ammonium IGNITE (150g/L) plus metribuzin SENCOR 500 F (500g/L) LEXONE DF (75 DF)	0.405 to 0.75 kg/ha 2.7 to 5 L/ha 0.55 kg/ha 1.1 L/ha 0.75 kg/ha	 1.08 to 2 L/ac 0.44 L/ac 0.3 kg/ac	See comments for IGNITE applied alone. Residual control of annual weeds may be obtained when IGNITE is tank mixed with SENCOR 500 F or LEXONE DF. Consult respective labels prior to application for further information. DO NOT use metribuzin on muck soils or on Belleisle or Tobique varieties.
metribuzin SENCOR 75 DF (75 WG) plus linuron LINURON 480 (480g/L) plus metolachlor DUAL (960g/L)	0.525 to 0.75 kg/ha 0.7 to 1 kg/ha 0.912 to 1.344 kg/ha 1.9 to 2.8 L/ha 1.92 to 2.88 kg/ha 2 to 3 L/ha	 0.28 to 0.4 kg/ac 0.76 to 1.12 L/ac 0.8 to 1.2 L/ac	Apply after hilling and before emergence of the crop. Emerged weeds should not be taller than 4 cm. DO NOT use on muck soils, or on sandy or coarse texture soils low in organic matter. Use a lower rate of metribuzin on sandy soil. Use only on late potato varieties. DO NOT use on Belleisle, Tobique, Superior, or red skinned varieties.
paraquat GRAMOXONE (200g/L)	0.6 to 0.85 kg/ha 3 to 4.25 L/ha	 1.2 to 1.7 L/ac	Apply in 275-550 L/ha (150-220 L/ac) water to emerged weeds. Use on Netted Gem and Cherokee varieties before emergence. Apply on other varieties until 25 to 30% of the crop has emerged but none of the tops should be over 5 to 8 cm in height. Temporary yellowing on the tops will occur. DO NOT use on emerged potato plants in the evening, under cloudy conditions or when the plants are under moisture stress.
s-metolachlor DUAL MAGNUM (915g/L) plus linuron LOROX DF (50 DF) AFOLAN F (480g/L) LINURON 480 (480g/L)	1.14 to 1.6 kg/ha 1.25 to 1.75 L/ha 0.88 to 1.12 kg/ha 1.75 to 2.25 kg/ha 1.8 to 2.3 L/ha 1.8 to 2.3 L/ha	 0.5 to 0.7 L/ac 0.7 to 0.9 kg/ac 0.72 to 0.92 L/ac 0.72 to 0.92 L/ac	See remarks for DUAL MAGNUM. For more information about linuron see the remarks for linuron. S-metolachlor as a tank mix should be applied before emergence of the crop and weeds after the first hilling.
s-metolachlor DUAL MAGNUM (915g/L) plus metobromuron PATORAN FL (400g/L)	1.14 to 1.6 kg/ha 1.25 to 1.75 L/ha 1.168 to 1.68 kg/ha 2.92 to 4.2 L/ha	 0.5 to 0.7 L/ac 1.17 to 1.68 L/ac	S-metolachlor as a tank mix should be applied before emergence of the crop and weeds after the first hilling. See remarks for DUAL MAGNUM. Use the lower rates on sandy soil.

s-metolachlor DUAL MAGNUM (915g/L) plus metribuzin SENCOR 500 F (500g/L) or metribuzin LEXONE DF (75 DF)	1.14 to 1.6 kg/ha 1.25 to 1.75 L/ha 0.55 to 1.125 kg/ha 1.1 to 2.25 L/ha 0.624 to 0.902 kg/ha 0.83 to 1.2 kg/ha	0.5 to 0.7 L/ac 0.44 to 0.9 L/ac 0.33 to 0.48 kg/ac	See remarks for DUAL MAGNUM. Apply as a preplant incorporated or preemergence treatment. The tankmix should not be used on the varieties SUPERIOR, BELLEISLE, TOBIQUE. DO NOT apply on sandy or on coarse textured soils low in organic matter or on muck soils. DO NOT apply at ground crack or if potatoes have emerged.
s-metolachlor DUAL MAGNUM (915g/L) plus monolinuron AFESIN (200g/L)	1.14 to 1.6 kg/ha 1.25 to 1.75 L/ha 1.1 to 1.7 kg/ha 5.5 to 8.5 L/ha	0.5 to 0.7 L/ac 2.2 to 3.4 L/ac	S-metolachlor as a tank mix should be applied before emergence of the crop and weeds after the first hilling. See remarks for DUAL MAGNUM.
[redacted]			
clethodim SELECT (240g/L) plus surfactant AMIGO	0.03 to 0.09 kg/ha 0.13 to 0.38 L/ha 0.5 to 1 % v/v	0.05 to 0.15 L/ac 0.5 to 1 % v/v	Potatoes are tolerant at any growth stage. Apply when the annual grasses and volunteer cereals are in the 2 to 6 leaf stage. Apply to quackgrass in the 2 to 5 leaf stage. Use the higher rate for control of quackgrass. Add the surfactant AMIGO at 0.5-1% v/v.
diclofop-methyl HOE-GRASS 284 (284g/L)	1 kg/ha 3.5 L/ha	1.4 L/ac	DO NOT USE IN TANK MIX WITH OTHER HERBICIDES. Apply when the majority of the grass weeds are in the 2 to 3 leaf stage. DO NOT apply if rain is expected within an hour of application. Other postemergence herbicides should be applied at least 4 days before or after diclofop-methyl applications.
fenoxaprop-p-ethyl EXCEL SUPER (80.5g/L)	0.054 kg/ha 0.67 L/ha	0.27 L/ac	Apply when majority of annual grasses are in the 1 to 6 leaf stage or until volunteer corn is up to 25 cm tall. DO NOT apply if rainfall is expected within one hour after application. Second flush annual grasses will not be controlled if emergence occurs after application.
fluazifop-p-butyl FUSILADE II (125g/L)	0.075 to 0.125 kg/ha 0.6 to 1 L/ha	0.24 to 0.4 L/ac	Apply to actively growing annual grasses at the 2 to 4 leaf stage for foxtails, and the 2 to 5 leaf stage for other. Best results are obtained when fluazifop-p-butyl is applied prior to tillering. Application beyond the 5 leaf stage will not provide control. Use the low rate for volunteer corn; the high rate for foxtails, wild oats, proso millet, and crabgrass; the median rate for other grasses. Fluazifop-p-butyl may be tank mixed with metribuzin for broad spectrum weed control apply at least 90 days before harvest.
fluazifop-p-butyl FUSILADE II (125g/L)	0.25 kg/ha 2 L/ha	0.8 L/ac	Rhizomes of quackgrass should be thoroughly fragmented by tillage prior to application. Apply to actively growing plants that have 3 to 5 leaves. DO NOT cultivate for at least 5 days after application. Fluazifop-p-butyl may be tank mixed with metribuzin. Apply at least 90 days before harvest.
sethoxydim POAST ULTRA (450g/L) plus oil concentrate ASSIST or surfactant/solvent MERGE	0.15 to 0.2 kg/ha 0.32 to 0.47 L/ha 2 L/ha 1 L/ha	0.13 to 0.19 L/ac 0.8 L/ac 0.4 L/ac	Potatoes are tolerant to sethoxydim at any stage of growth. Apply sethoxydim to emerged grasses in the 1 to 6 leaf stage during active growth while the crop is small enough to permit thorough spray coverage. Complete control is normally obtained 7 to 21 days after treatment. Apply using 110-200 L/ha (44-80 L/ac) water. Use the higher rate for volunteer cereal control.

Active Ingredient TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACRE	PRECAUTIONS (For more information, see "Notes on Chemicals" section.)
sethoxydim POAST ULTRA (450g/L) plus surfactant/solvent MERGE	0.5 kg/ha 1.1 L/ha 1 to 2 L/ha	 0.45 L/ac 0.4 to 0.8 L/ac	Thorough preplant tillage will provide more uniform quackgrass emergence. Apply at the 1 to 3 leaf stage of actively growing quackgrass. Apply in 110-200 L/ha (44-80 L/ac) water. Use MERGE at a rate of 1% v/v. Crop competition and inter-row cultivation 7 to 14 days after application will provide quackgrass control for 6 to 8 weeks.
Postemergent Grass and Broadleaf Herbicides			
metribuzin SENCOR 500 F (500g/L) or metribuzin LEXONE DF (75 DF)	0.6 to 1.1 kg/ha 1.2 to 2.2 L/ha 0.624 to 0.772 kg/ha 0.83 to 1.03 kg/ha	 0.48 to 0.88 L/ac 0.33 to 0.4 kg/ac	Apply early postemergence soon after emergence of the crop and before weeds are 4 cm high. Applications should be made in the afternoon or early evening on sunny days (this allows the enzyme that detoxifies metribuzin to build-up). DO NOT use postemergence on red skinned varieties or on potatoes grown for the early market, or on the Shepody or Atlantic, variety. DO NOT USE ON MUCK SOIL as a residue may injure vegetable crops sown the following season.
rimsulfuron PRISM (25 DF) plus non-ionic surfactant	15 g/ha 60 g/ha 2 L/1000L	 24 g/ac 2 L/1000L	Add a non-ionic surfactant at 2 L per 1000 L of spray solution (0.2% v/v). Always add water soluble packages to clean water with the agitator running. Apply to potatoes prior to initiation of flowering when quackgrass is at 3 to 6 leaf stage (less than 10 cm tall), annual grasses are at 1 to 6 leaf stage and redroot pigweed is in the 4 to 6 leaf stage. DO NOT apply within 30 days of harvest.
Rutabaga			
PREPLANT - See under PREPLANT - SITE PREPARATION for details of products, rates and remarks.			
PREPLANT INCORPORATED - Two incorporations at right angles operating at a depth of 10 cm using a double disk (7-10 km/hour) or vibrating shank S-tine cultivator (10-13 km/hour) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness, and/or treating fields with perennial weeds last.			
PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.			
Soil Applied Grass and Broadleaf Herbicides			
s-metolachlor DUAL MAGNUM (915g/L)	1.14 to 1.6 kg/ha 1.25 to 1.75 L/ha	 0.5 to 0.7 L/ac	Apply and incorporate DUAL MAGNUM thoroughly before planting or apply preemergence to the weeds . To control nutsedge and annual nightshade..
Soil Applied Grass and Broadleaf Herbicides			
napropamide DEVRINOL DF (50 DF)	1.12 to 2.25 kg/ha 2.25 to 4.5 kg/ha	 0.9 to 1.8 kg/ac	Use lower rates on sandy soils. Apply to well worked soil that is dry enough to permit thorough incorporation to a depth of 2.5 to 5 cm. Incorporate the same day as applied. After harvest, soil should be worked (across the rows if banded) to prevent injury to succeeding crops. Small grains seeded in the fall may be stunted but not otherwise affected.
trifluralin TREFLAN (480g/L) RIVAL DF (60 DF) BONANZA 400 (400g/L)	0.818 to 1.155 kg/ha 1.7 to 2.4 L/ha 1 to 1.9 kg/ha 2 to 2.75 L/ha	 0.68 to 0.96 L/ac 0.4 to 0.76 kg/ac 0.8 to 1.1 L/ac	See: "Notes on Chemicals" section for details. If shallow cultivation is to be used to control additional broadleaf weeds, it should start when the weeds have reached the 3 to 4 leaf stage. Controls triazine resistant pigweed. Apply and incorporate as directed above.
Postemergent Grass Herbicides			
fluazifop-p-butyl FUSILADE II (125g/L)	0.125 kg/ha 1 L/ha	 0.4 L/ac	Apply at 2-5 leaf stage of annual grasses. Inter-row cultivation should not occur until 5 days after application. Apply other postemergence herbicides separately at least 3 days after FUSILADE II.

fluazifop-p-butyl FUSILADE II (125g/L)	0.25 kg/ha 2 L/ha	0.8 L/ac	Apply at 3-5 leaf stage of quackgrass and wire stemmed muhly. Thorough preplant tillage to fragment quackgrass rhizomes improves control. Inter-row cultivation should not occur until 5 days after application. Apply other postemergence herbicides separately at least 3 days after FUSILADE II.
clopyralid LONTREL 360 (360g/L)	0.2 kg/ha 0.56 L/ha	0.22 L/ac	Apply when ragweed plants are 5-10 cm tall. Make only one application per season. Pre-harvest interval is 83 days. For a broad spectrum weed control use as a follow up to a trifluralin or metolachlor application.

Specialty Vegetables

Includes Chinese broccoli, Chinese cabbage, kohlrabi, mustard cabbage, Chinese radish, fuzzy squash and snow peas.

PREPLANT - See under PREPLANT - SITE PREPARATION for details of products, rates and remarks.

PREPLANT INCORPORATED - Two incorporations at right angles operating at a depth of 10 cm using a double disk (7-10 km/hour) or vibrating shank S-tine cultivator (10-13 km/hour) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness, and/or treating fields with perennial weeds last.

PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

imazethapyr PURSUIT (240g/L)	0.075 kg/ha 0.312 L/ha	0.125 L/ac	Only apply once per year. Apply in 200 L/ha (80 L/ac). Allow a preharvest interval of 60 days. For use on snow peas only.
napropamide DEVRINOL DF (50 DF)	1.12 to 2.25 kg/ha 2.25 to 4.5 kg/ha	0.9 to 1.8 kg/ac	Apply either preplant or preemergence. Consult product label for more information. Use the lower rate on light soils (coarse textured-sandy and sandy loam). One application per year ground only. DO NOT harvest within 60 days. Usual rotational crop restrictions apply. After harvest, soil should be worked (across rows if banded) to prevent injury to succeeding crops. Small grains seeded in the fall may be stunted but not otherwise affected. Use on seeded Chinese broccoli, mustard, cabbage, Chinese radish, Chinese cabbage, transplanted Chinese cabbage and kohlrabi.
napropamide DEVRINOL DF (50 DF)	1.5 kg/ha 3 kg/ha	1.2 kg/ac	Requires rainfall or sufficient irrigation to wet the soil to a depth of 5 to 10 cm soon after application. Some crop stunting may be observed but this should not affect yield. For use on fuzzy squash only.
sethoxydim POAST ULTRA (450g/L) plus surfactant/solvent MERGE	0.15 to 0.2 kg/ha 0.32 to 0.47 L/ha 1 L/ha	0.13 to 0.19 L/ac 0.4 L/ac	Crops are tolerant to sethoxydim at any stage of growth. Apply sethoxydim to emerged grasses in the 1 to 6 leaf stage during active growth while crop is small enough to permit thorough spray coverage. Complete control is normally obtained 7 to 21 days after treatment. Apply using 110-200 L/ha (44-80 L/ac) water volume. Use on Chinese broccoli, Chinese cabbage, kohlrabi, mustard cabbage and Chinese radish only.

Active Ingredient TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACRE	PRECAUTIONS (For more information, see "Notes on Chemicals" section.)
sethoxydim POAST ULTRA (450g/L) plus surfactant/solvent MERGE	0.5 kg/ha 1.1 L/ha 1 to 2 L/ha	 0.45 L/ac 0.4 to 0.8 L/ac	Thorough preplant tillage will provide more uniform quackgrass emergence. Apply at the 1 to 3 leaf stage of actively growing quackgrass in 110-200 L/ha (44-80 L/ac) water. Use MERGE at a rate of 1% v/v. Crop competition and inter-row cultivation 7 to 14 days after application will provide quackgrass control for 6 to 8 weeks. Use on Chinese broccoli, Chinese cabbage, kohlrabi, mustard cabbage and Chinese radish only.
Foliage or Broadcast Herbicides			
clopyralid LONTREL 360 (360g/L)	0.20 kg/ha 0.56 L/ha	 0.2 L/ac	Nappa Cabbage, Chinese Radish, Mustard Cabbage, Chinese Broccoli - Apply as a ground application in 300 L water/ha. Use only one application per year, no closer than 30 days to harvest. Treat when weeds are young and actively growing. Will not control weeds that emerge after treatment.

Spinach

PREPLANT - See under PREPLANT - SITE PREPARATION for details of products, rates and remarks.

PREPLANT INCORPORATED - Two incorporations at right angles operating at a depth of 10 cm using a double disk (7-10 km/hour) or vibrating shank S-tine cultivator (10-13 km/hour) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness, and/or treating fields with perennial weeds last.

PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

Soil Applied Grass Herbicides			
cycloate RO-NEET (720g/L)	3.4 kg/ha 4.75 L/ha	 1.9 L/ac	Preplant incorporated on mineral soils only. RO-NEET should be applied to a dry soil surface before planting, and incorporated within 10 minutes with a double disk. A second incorporation at right angles in tandem with a harrow should follow as soon as possible. Use the lower rate on sandy soils.
Soil Applied Broadleaf Herbicides			
chlorpropham CIPC EC (480g/L)	1.3 to 5 kg/ha 2.7 to 10.4 L/ha	 1.08 to 4.16 L/ac	Preemergence on mineral soils only. Chlorpropham should be used at higher rates during warm weather (between May 1 to October 15) on heavy soils. Use lower rates during cool season (between October 15 to May 1) and on sandy loam soils.

Sugar beets (Processing)

PREPLANT - See under PREPLANT - SITE PREPARATION for details of products, rates and remarks.

PREPLANT INCORPORATED - Two incorporations at right angles operating at a depth of 10 cm using a double disk (7-10 km/hour) or vibrating shank S-tine cultivator (10-13 km/hour) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness, and/or treating fields with perennial weeds last.

PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

Soil Applied Grass Herbicides

cycloate RO-NEET (720g/L)	4.5 to 5.58 kg/ha 6.25 to 7.75 L/ha	 2.5 to 3.1 L/ac	Use mineral soils only. Apply in 200 to 400 L/ha (80-160 L/ac) water. Incorporate immediately. Use lower rate on sandy soil. DO NOT apply ethofumesate preemergence.
pyrazon PYRAMIN FL (430g/L)	3.55 to 4.41 kg/ha 8.25 to 10.25 L/ha	 3.3 to 4.1 L/ac	Apply to moist soil in 200 to 500 L/ha (80-200 L/ac) water. Use lower rate on soils less than 3% matter. Incorporate ppi applications no deeper than 5 cm. Can be applied pre and ppi. Pre applications require rainfall or irrigation for activation.
ethofumesate NORTRON SC (480 g/L)	1.54 to 3.96 kg/ha 3.2 to 8.25 L/ha	 1.28 to 3.3 L/ac	For mineral soils only. Can be applied pre and ppi. Incorporate ppi applications shallowly. Use lower rate on soil with less than 3% organic matter. Apply in 110 to 560 L/ha (44-224 L/ac) water. DO NOT rotate to other crops for 12 months.
ethofumesate NORTRON SC (480 g/L) plus cycloate RO-NEET (720g/L)	1.41 to 2.88 kg/ha 3.5 to 6 L/ha 3.75 to 5.25 kg/ha 5.2 to 7.3 L/ha	 1.4 to 2.4 L/ac 2.1 to 2.9 L/ac	Use on mineral soils only. Use lower rates on soils less than 3% organic matter. Apply in 110 to 560 L/ha (44-224 L/ac) water and incorporate shallowly. DO NOT rotate to other crops for 12 months.
pyrazon PYRAMIN FL (430g/L) plus ethofumesate NORTRON SC (480g/L)	2.26 kg/ha 5.25 L/ha 1.75 kg/ha 3.65 L/ha	 2.1 L/ac 1.46 L/ac	Make one application per year before weeds emerge. Do not apply to soil with less than 2% organic matter. Do not rotate to crops other than sugar beets for 12 months after application.
quizalofop p-ethyl ASSURE II (96g/L) plus CANPLUS 411 or SURE-MIX	0.036 to 0.072 kg/ha 0.38 to 0.75 L/ha 5 - 10 L/1000L 5 L/1000L	 0.15 to 0.30 L/ac 5 - 10 L/1000L 5 L/1000L	Apply to emerged annual grasses and volunteer cereals in 2 leaf to tillering stage and volunteer corn and quackgrass in the 2 to 6 leaf stage. Apply before the crop canopy closes to maximize spray coverage. Use the 0.15 L/ac rate for control of annual grasses and volunteer cereals. Use the 0.3 L/ac rate to control annual grasses, volunteer cereals and quackgrass. If a second flush of annual grasses or volunteer cereals is observed, apply an additional (sequential) application of ASSURE II at 0.15 L/ac. DO NOT exceed an accumulative, seasonal use rate of 0.3 L/ac of ASSURE II per year. DO NOT apply within 80 days of harvest.
sethoxydim POAST ULTRA (450g/L) plus surfactant/solvent MERGE	0.15 to 0.2 kg/ha 0.32 to 0.47 L/ha 0.5 to 1 L/ha	 0.13 to 0.19 L/ac 0.2 to 0.4 L/ac	Apply in 50 to 110 L/ha (20-44 L/ac) water. Grasses should be actively growing in the 2-5 leaf (annual grass) stage. DO NOT apply within 85 days of harvest.

Active Ingredient TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACRE	PRECAUTIONS (For more information, see "Notes on Chemicals" section.)
sethoxydim POAST ULTRA (450g/L) plus surfactant/solvent MERGE	0.5 kg/ha 1.1 L/ha 0.5 to 1 L/ha	 0.45 L/ac 0.2 to 0.4 L/ac	Grasses should be actively growing in the 3 leaf (quackgrass) stage.
clopyralid LONTREL 360 (360g/L)	Consult label and your processor for application rates		Emerged Canada thistle. Apply when sugar beets are in cotyledon to 8 leaf stage. DO NOT apply within 90 days of harvest.
desmedipham BETANEX (150 g/L)	Consult label and your processor for application rates		Pigweed, lamb's-quarters, mustard. Apply in 200 to 400 L/ha (80-160 L/ac) water before weeds have 4 true leaves, after sugar beets have at least 2 true leaves. Can apply a 2nd application at least 7 days later.
pyrazon PYRAMIN FL (430g/L) plus surfactant CITOWETT PLUS	Consult label and your processor for application rates		Apply after beets have 2.5 cm true leaves, but before weeds have 3 true leaves. Use 300 to 400 L/ha (120-160 L/ac) water. Avoid hot temperatures. DO NOT use on soils with less than 3% organic matter.
triflusulfuron-methyl UPBEET (50 DF) plus desmedipham/phenmedipham BETAMIX ((1:1) 150g/L)	17.5 to 35 g/ha 35 to 70 g/ha 0.26 to 0.53 kg/ha 1.75 to 3.5 L/ha	 14 to 28 g/ac 0.7 to 1.4 L/ac	Make 2 applications 5 to 10 days apart, or as weeds emerge, to weeds less than 4 leaves. Best control is obtained if weeds have less than 2 leaves. Use the closer sequential if the first application was applied to 5 cm (4 true leaves) weeds. Use the higher rate for larger weeds and denser weed populations. Do not use an adjuvant with this tankmix. Do not use more than 100 g/ha of UPBEET in a season. Apply to actively growing weeds and sugar beets. Yellowing of the crop may occur, but sugar beets will recover. Timely cultivation will improve weed control. Do not apply closer than 60 days to harvest.
triflusulfuron-methyl UPBEET (50 DF) plus non-ionic surfactant AGRAL 90, AG-SURF or CITOWETT PLUS or plus adjuvant SURE-MIX	17.5 to 35 g/ha 35 to 70 g/ha 0.25% v/v 2.5 L/1000 L 0.25% v/v 2.5 L/1000 L	 14 to 28 g/ac 2.5 L/1000 L 2.5 L/1000 L	Velvetleaf. Make 2 applications 5-10 days apart. Apply when velvetleaf has less than 2 leaves. Use the higher rate for larger weeds and denser weed populations. Do not use more than 100 g/ha of UPBEET in a season. Apply to actively growing weeds and sugar beets. Yellowing of the crop may occur, but sugar beets will recover. Do not apply closer than 60 days to harvest.
desmedipham/phenmedipham (1:1) BETAMIX (75 g/L: 75 g/L)	Consult label and your processor for application rates		Apply in 200 to 400 L/ha (80-160 L/ac) water after sugar beets have at least 2 true leaves. Best results when weeds have less than 2 true leaves. Temporary injury may result. Can apply a 2nd applications at least 7 days.
desmedipham/phenmedipham (1:1) BETAMIX (75 g/L: 75 g/L) plus endothall HERBICIDE 273 (360g/L)	Consult label and your processor for application rates		Apply in 200 to 400 L/ha (80-160 L/ac) water after beets have at least 2 true leaves. Best results when weeds have less than 2 true leaves. Use lower rates on smaller beets, or beets under stress.

endothall HERBICIDE 273 (360g/L)	Consult label and your processor for application rates	Apply in 90 to 250 L/ha (36-100 L/ac) water when beets are in the 4-6 leaf stage, but before weeds are large. DO NOT apply later than 40 days after emergence. Temporary injury may result.

Active Ingredient TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACR	PRECAUTIONS (For more information, see "Notes on Chemicals" section.)

Sweet Corn

All treatments should be applied in 150 to 300 L/ha (60-120 L/ac) water unless otherwise specified.

Any single method of weed control or the continuous use of the same chemicals can lead to the build up of weeds resistant or tolerant to that control method. Triazine-resistant lamb's-quarters and pigweed have become a problem as a result of continuous corn and the repeated use of triazine herbicides. Rotation to other crops and/or other control methods will reduce the chance of new or unique weed infestations.

Blind harrowing with a set of light harrows operating at a shallow depth before the corn has emerged, or using a weeder harrow (with L shaped flexible tines) when the crop is 5-10 cm high can also help control small annual weed seedlings. High speed (10 kph), shallow (2.5-3cm) cultivation with the rotary hoe when corn is 7- 8 cm in height will help to control small weed seedlings. These techniques will not reduce herbicide action and may in some years enhance chemical weed control. Inter-row cultivation can be used to complement other weed control measures. Row cultivation is most effective when weeds are small. Cultivation should be shallow to reduce the germination of new weed seeds, to reduce moisture loss and to reduce corn root injury. Inter-row cultivation may be required when weeds escape herbicide treatment; weeds should be considered as escapes when they are 5- 7 cm high.

Band treatment of chemical over the row will reduce cost by one-half to two-thirds, depending on the row spacing and width of band. Shallow inter-row cultivation will be required to control weeds between the bands.

Cultivation will give some control of established perennial weeds but may also help to spread them to previously uninfested areas. Machinery sanitation is important when moving from one field to another. Many perennials (i.e. nutsedge) can be spread on tillage equipment. Custom operators should be particularly careful when moving from one farm to another

Sweet corn most frequently is grown in areas where the crops in sequence are very sensitive to atrazine residues. Avoid using atrazine rates above 1.1 kg/ha (active) (2.3 L/ha (0.92 L/ac) of 480 g/L) or
1.2 kg/ha (0.48 kg/ac) of (90 WG) product. (See notes on atrazine residues for suggestions).

For information on specific weeds see the Sweet Corn Herbicide Weed Control Ratings Table and then refer to the appropriate section for details about herbicide treatment.

NITROGEN solution can be used as a carrier, instead of water, for preplant and preemergence application of some herbicides. Weed control activity is not increased. Spraying should be done before crop emergence. Consult the herbicide label as to the proper methods of application and use of dispersing agents. Calibrate the sprayer to apply the required amount of NITROGEN. Stainless steel flood jet nozzles of adequate size (e.g. Teejet TK SS 5 to TK SS 10) should be used. The NITROGEN solution is mildly corrosive, especially to brass, and the sprayer should be cleaned immediately after use. UNITE may be used as an aid in improving liquid fertilizer herbicide compatibility and stability when a simultaneous application of a liquid fertilizer and liquid or wettable powder herbicide is desired. Because formulations and rates vary, it is essential to read the label to determine the exact amount and method to be used. DO NOT apply with postemergence herbicides.

SPECIAL NOTES FOR SWEET CORN

TRIAZINE-RESISTANT ANNUAL WEEDS: Strains of lamb's-quarters, pigweed, ragweed and old witch grass have been found that are resistant to high rates of all TRIAZINE herbicides including atrazine, cyanazine and simazine. These triazine-resistant species have been found in corn growing areas across Ontario. These strains cannot be visibly distinguished from the susceptible strains. Preemergence treatment with linuron or postemergence treatment with bromoxynil, or directed linuron will usually give control of the broadleaf species (see appropriate sections above). The grasses can be controlled with EPTC+, or metolachlor (see sections above.).

NOTES ON ATRAZINE AND SIMAZINE SOIL RESIDUES: Atrazine and simazine residues may last for more than one year, particularly if high rates are used more than once and dry weather occurs. If atrazine or simazine is used year after year as in a continuous corn program, triazine residues may be higher. Atrazine when used at rates from 1.2 to 1.5 kg/ha (active) (2.4 to 3.0 L/ha (0.96-1.2 L/ac) of (500 g/L) or 1.2 to 1.7 kg/ha (0.48-0.68 kg/ac) of (90 WG) PRODUCT) on corn generally has not caused injury on succeeding crops of oats, barley, mixed grains, or soybeans, except in years where there was very little rain the previous fall which would slow down atrazine degradation in the soil. Postemergence treatments may persist longer than preemergence treatments. Variations from this generality of 1.2 to 1.5 kg/ha atrazine may occur across the province.

Injury has been reported on tomatoes, white beans, forage seedings, peas, tobacco, cucumbers, onions, and turnips following applications of atrazine at more than 1.1 kg/ha (active)(2.3 L/ha (0.96 L/ac) of (480 g/L) or 1.2 kg/ha (0.48 kg/ac) of (90 WG) PRODUCT) on corn the previous year. To reduce the hazard of atrazine residues on succeeding crops:

1. Apply the early postemergence atrazine oil-water treatment with the lower rate of atrazine: 1.1. kg/ha (active) (2.2 L/ha (0.88 L/ac) of (500gL) or 1.2 kg/ha (0.48 kg/ac) of (90 WG) PRODUCT). With this lower rate, a lower measure of weed control may result and cultivation may be necessary.

2. Fall plowing will reduce TRIAZINE injury more than will spring plowing.

3. Mold board plowing will disperse herbicide residue to a greater soil depth than chisel plowing, thus reducing the concentration of herbicide in the upper soil area.

4. Ensure that the sprayer used is adequate and is properly calibrated and adjusted. Spray uniformly without overlaps and do not spray while the sprayer is stopped.

If a residue problem is anticipated, contact your local Extension Personnel for information on soil analysis procedures for triazine residues.

PREPLANT - See under PREPLANT - SITE PREPARATION for details of products, rates and remarks.

PREPLANT INCORPORATED - Two incorporations at right angles operating at a depth of 10 cm using a double disk (7-10 km/hour) or vibrating shank S-tine cultivator (10-13 km/hour) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness, and/or treating fields with perennial weeds last.

PREEMERGENCE - Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes
and improve herbicide activity in the absence of rainfall.

Burndown and Residual Control

Refer to the "conservation tillage section" for information on treatments specific for use in conservation tillage systems, no-till, minimum-till, ridge-till.

glyphosate ROUNDUP (356g/L) plus s-metolachlor/benoxacor DUAL II MAGNUM (915g/L) and plus atrazine AATREX NINE-O (90WG) or plus s-metolachlor/benoxacor/ atrazine PRIMEXTRA II MAGNUM ((1:0.8)720g/L)	0.836 to 0.89 kg/ha 2.35 to 2.5 L/ha 1.14 to 1.6 kg/ha 1.25 to 1.75 L/ha 1 to 1.53 kg/ha 1.11 to 1.7 kg/ha 2.16 to 2.88 kg/ha 3 to 4 L/ha in 200 L water/ha	 0.94 to 1 L/ac 0.5 to 0.7 L/ac 0.44 to 0.68 kg/ac 1.2 to 1.6 L/ac in 80 L water/ac	Use the higher rate of s-metolachlor/benoxacor for heavier weed populations. Use higher rate of glyphosate when perennial weeds are present. Many broadleaf perennial weeds may not be controlled at this time and rate of application.
metolachlor DUAL (960g/L) plus cyanazine BLADEX 90 DF (90 DF)	1.92 to 2.64 kg/ha 2 to 2.75 L/ha 1.8 to 2.25 kg/ha 2 to 2.5 kg/ha	 0.8 to 1.1 L/ac 0.8 to 1 kg/ac	Apply pre-plant burndown application only when emerged weeds are less than 6 cm tall. If emerged annual weeds are taller than 6 cm apply glyphosate prior to the tank mix application. For improved burndown of small emerged annual weeds, the following additives may be applied: Crop oil 28-0-0 or 10-34-0 at 5% volume/volume; Crop oil concentrate at 1% volume/volume; Non-ionic surfactant at 0.1% volume/volume. Use higher rates of metolachlor for heavier weed populations.
metolachlor DUAL (960g/L) plus glyphosate TMS TOUCHDOWN 480 (330g/L)	1.92 to 2.64 kg/ha 2 to 2.75 L/ha 0.77 to 0.83 kg/ha 2.35 to 2.5 L/ha	 0.8 to 1.1 L/ac 0.94 to 1 L/ac	Use the higher rate of metolachlor for heavier weed populations. Use higher rate of glyphosate TMS when perennial weeds are present.
paraquat GRAMOXONE (200g/L) plus atrazine AATREX NINE-O (90WG) AATREX (480g/L) ATRAZINE 480 (480g/L)	0.55 to 1.1 kg/ha 2.75 to 5.5 L/ha 1.53 kg/ha 1.7 kg/ha 3.18 L/ha 3.18 L/ha	 1.1 to 2.2 L/ac 0.68 kg/ac 1.27 L/ac 1.27 L/ac	Apply at least 3 days prior to crop emergence. Some perennial species may escape (alfalfa, bromegrass and orchard grass). Consideration should be given to follow up treatments when the corn is at the approximate stage of growth with herbicide treatments recommended for use in the conventional tillage corn section. Apply in 325 to 500 L/ha of water (130 to 200 L/ac)

Active Ingredient TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACR	PRECAUTIONS (For more information, see "Notes on Chemicals" section.)
s-metolachlor/benoxacor		1.14 to 1.6 kg/ha	Apply pre-plant burndown application only when emerged weeds are less than 6 cm tall. If emerged annual weeds are taller than 6 cm apply glyphosate prior to the tank mix application or make an application of 3-way tank mix of s-metolachlor/benoxacor plus atrazine plus glyphosate. For improved burndown to small emerged annual weeds, the following additives may be applied: Crop oil, 28-0-0 or 10-34-0 at 5% volume/volume; Crop oil concentrate at 1 % volume/volume; Non-ionic surfactant at 0.1% volume/volume. Use higher rates for heavier weed populations.
DUAL II MAGNUM (915g/L)	1.25 to 1.75 L/ha	0.5 to 0.7 L/ac	
plus atrazine	1 to 1.53 kg/ha		
AATREX NINE-O (90WG)	1.11 to 1.7 kg/ha	0.44 to 0.68 kg/ac	
s-metolachlor/benoxacor	1.14 to 1.6 kg/ha		Use the higher rate of s-metolachlor/benoxacor for heavier weed populations. Use higher rate of glyphosate when perennial weeds are present. Apply in 200 L/ha (80 L/ac)of water.
DUAL II MAGNUM (915g/L)	1.25 to 1.75 L/ha	0.5 to 0.7 L/ac	
plus glyphosate	0.836 to 0.89 kg/ha		
ROUNDUP (356g/L)	2.35 to 2.5 L/ha	0.94 to 1 L/ac	
Soil Applied Grass Herbicides			
dimethenamid	1 to 1.25 kg/ha		Apply PPI or PRE. Incorporation equipment should be set to work soil no deeper than 10 cm. Control of yellow nutsedge is obtained when FRONTIER is applied PPI. Minimum PPI rate is 1.125 kg/ha. Use the higher rate of FRONTIER for the control of nightshade and pigweed. DO NOT use on muck, peat, or high organic matter soils. See tank mixes for treatments to provide annual broadleaf control or follow with sequential postemergence broadleaf herbicide. DO NOT USE ON SEED CORN OR POPCORN.
FRONTIER (900g/L)	1.1 to 1.4 L/ha	0.44 to 0.56 L/ac	
EPTC/ R25788 (EPTC+)	3.4 to 4.4 kg/ha		Must be preplant incorporated. See "Notes on Chemicals". DO NOT USE ON SEED CORN.
ERADICANE (800g/L)	4.25 to 5.5 L/ha	1.7 to 2.2 L/ac	
EPTC/ R25788 (EPTC+)	2.4 kg/ha		Must be preplant incorporated. See "Notes on Chemicals". DO NOT USE ON SEED CORN.
ERADICANE (800g/L)	3 L/ha	1.2 L/ac	
plus metolachlor	0.72 kg/ha		
DUAL (960g/L)	0.75 L/ha	0.3 L/ac	
s-metolachlor/benoxacor	1.14 to 1.6 kg/ha		Apply PPI or PRE. Incorporation equipment should be set to work soil no deeper than 10 cm. Control of yellow nutsedge is obtained when DUAL II MAGNUM is applied PPI. Optimal control of nightshade is obtained when DUAL II MAGNUM is applied PRE. DO NOT use on muck, peat, or high organic matter soils. See tank mixes for treatments to provide annual broadleaf control or follow with sequential postemergence broadleaf herbicide.
DUAL II MAGNUM (915g/L)	1.25 to 1.75 L/ha	0.5 to 0.7 L/ac	
Soil Applied Broadleaf Herbicides			
atrazine	1.01 to 1.49 kg/ha		Apply PRE. Weeds will normally emerge and die within a few days; atrazine can persist for varying lengths of time; longer under dry, cool weather and coarse textured soils. See tank mixes for reducing rates and avoiding residues, and for treatments to provide annual grass control.
ATRAZINE 480 (480g/L)	2.1 to 3.1 L/ha	0.84 to 1.24 L/ac	
AATREX NINE-O (90WG)	1.12 to 1.65 kg/ha	0.45 to 0.66 kg/ac	
simazine	1.35 to 2.25 kg/ha		Apply PRE or PPI. These products are listed separately because of their widely differing rate ranges. In both cases the low rates should be used on sandy soils while the higher rates may be used. on loams and clays Full season annual weed control can be expected except for crabgrass of fall panicum where infestations have built up. Caution is advised when considering rates beyond 20 kg/ha (0.8 kg/ac) as soil residues may be high. Read "Notes on atrazine and simazine soil residue" at the start of the corn section.
PRINCEP NINE-T (90WG)	1.5 to 2.5 kg/ha	0.6 to 1 kg/ac	
or simazine	1.6 to 4 kg/ha		
SIMADEX (500g/L)	3.2 to 8 L/ha	1.28 to 3.2 L/ac	
SIMAZINE 480 (480g/L)	3.4 to 8.3 L/ha	1.36 to 3.32 L/ac	

Soil Applied Grass and Broadleaf Herbicides

cyanazine BLADEX 90 DF (90 DF)	2.25 to 2.7 kg/ha 2.5 to 3 kg/ha	 1 to 1.2 kg/ac	Apply PRE. Barnyard grass and redroot pigweed may escape. Use the low rate on coarse textured soils and on sweet corn. Cyanazine is not recommended alone for fine textured or muck soils. See other treatments for appropriate tank mixes.
cyanazine BLADEX 90 DF (90 DF) BLADEX LIQUID (480g/L) plus atrazine ATRAZINE 480 (480g/L) AATREX NINE-O (90WG)	2.11 to 2.64 kg/ha 2.35 to 3 kg/ha 4.4 to 5.5 L/ha 1.128 to 1.3 kg/ha 2.35 to 2.7 L/ha 1.25 to 1.44 kg/ha	 0.94 to 1.2 kg/ac 1.76 to 2.2 L/ac 0.94 to 1.08 L/ac 0.5 to 0.58 kg/ac	Apply PPI at these rates. This combination will improve barnyard grass and pigweed control over cyanazine alone. Use the lower rate of both cyanazine and atrazine on coarse textured soils and the higher rates on medium to fine textured soils. DO NOT use on muck or peat soils. Mid season (July) germinating fall panicum may not be controlled.
cyanazine BLADEX 90 DF (90 DF) plus atrazine ATRAZINE 480 (480g/L) AATREX NINE-O (90WG)	1.8 to 2.25 kg/ha 2 to 2.5 kg/ha 1.2 to 1.49 kg/ha 2.5 to 3.1 L/ha 1.35 to 1.65 kg/ha	 0.8 to 1 kg/ac 1 to 1.24 L/ac 0.54 to 0.66 kg/ac	Apply PRE. The tank mix of cyanazine plus atrazine will improve control on fine textured soils and control of barnyard grass and redroot pigweed. DO NOT use the mixture on muck or peat soils. Fall panicum or velvetleaf may not be controlled for the full season.
dimethenamid FRONTIER (900g/L) plus atrazine AATREX NINE-O (90WG)	1 to 1.25 kg/ha 1.1 to 1.4 L/ha 1 to 1.53 kg/ha 1.11 to 1.7 kg/ha	 0.44 to 0.56 L/ac 0.44 to 0.68 kg/ac	Apply PREPLANT. Use the higher rate of dimethenamid for heavier weed populations. Control of non-emerged triazine resistant weeds will be limited to pigweed. For improved burndown control the addition of glyphosate may be required.
EPTC/ R25788 (EPTC+) ERADICANE (800g/L) plus atrazine ATRAZINE 480 (480g/L) AATREX NINE-O (90WG)	3.4 to 6.8 kg/ha 4.25 to 8.5 L/ha 1.2 to 1.49 kg/ha 2.5 to 3.1 L/ha 1.35 to 1.65 kg/ha	 1.7 to 3.4 L/ac 1 to 1.24 L/ac 0.54 to 0.66 kg/ac	Apply PPI. For suppression of moderate to heavy infestations of wild proso millet, use the higher rate of EPTC+ with atrazine. For most effective suppression of proso millet delay treatment and planting until mid to late May. Cultivation or a directed post application of linuron may be required to control later emerging proso millet.
EPTC/ R25788 (EPTC+) ERADICANE (800g/L) plus cyanazine BLADEX LIQUID (480g/L) BLADEX 90 DF (90 DF)	6.8 kg/ha 8.5 L/ha 2 to 2.25 kg/ha 4.25 to 4.7 L/ha 2.25 to 2.5 kg/ha	 3.4 L/ac 1.7 to 1.9 L/ac 0.9 to 1 kg/ac	Apply PPI. For increased control of proso millet, an inter-row cultivation should be used.
linuron AFOLAN F (480g/L)	1.803 to 2.26 kg/ha 3.75 to 4.7 L/ha	 1.5 to 1.88 L/ac	Apply PRE. Annual grasses, ragweed and velvetleaf are partially controlled but are the first to escape, particularly if low rates of the herbicide are used. DO NOT use on sandy soils. Seed corn at least 4 cm deep. Heavy rainfall and adverse weather conditions may result in temporary crop injury. See label and notes on sweet corn for information for use on sweet corn.

Active Ingredient TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACR	PRECAUTIONS (For more information, see "Notes on Chemicals" section.)
linuron LOROX DF (50 DF) linuron LINURON 480 (480g/L) plus atrazine ATRAZINE 480 (480g/L) AATREX NINE-O (90WG)	1.082 kg/ha 2.2 kg/ha 1.08 to 1.56 kg/ha 2.25 to 3.25 L/ha 1.1 kg/ha 2.29 L/ha 1.22 kg/ha	 0.88 kg/ac 0.9 to 1.3 L/ac 0.92 L/ac 0.49 kg/ac	Apply PRE. Use this tank mix only on clay or clay loam soil to avoid injury. This tank mix controls annual weeds including triazine resistant redroot pigweed and lamb's-quarters and is a method of or reducing atrazine residues. Annual grasses will be the first weeds to escape. See precautions for linuron alone.
metolachlor DUAL (960g/L) plus cyanazine BLADEX LIQUID (480g/L) BLADEX 90 DF (90 DF)	1.92 to 2.64 kg/ha 2 to 2.75 L/ha 1.8 to 2.7 kg/ha 3.75 to 5.5 L/ha 2 to 3 kg/ha	 0.8 to 1.1 L/ac 1.5 to 2.2 L/ac 0.8 to 1.2 kg/ac	Apply PPI or PRE. The maximum rate for preemergence application of cyanazine is 2.25 kg ai/ha. Metolachlor controls the grasses and cyanazine controls the broadleaf weeds. Use the high rates of cyanazine for heavy weed infestations or on fine textured soils. The PPI treatment will give control of proso millet. The PRE treatment may not control fall panicum all season long. See comments at beginning about mixing fertilizers.
s-metolachlor/benoxacor DUAL II MAGNUM (915g/L) plus atrazine ATRAZINE 480 (480g/L) AATREX NINE-O (90WG) or s-metolachlor/benoxacor/ atrazine PRIMEXTRA II MAGNUM ((1:0.8)720g/L)	1.14 to 1.6 kg/ha 1.25 to 1.75 L/ha 1.01 to 1.49 kg/ha 2.1 to 3.1 L/ha 1.12 to 1.65 kg/ha 2.16 to 2.88 kg/ha 3 to 4 L/ha	 0.5 to 0.7 L/ac 0.84 to 1.24 L/ac 0.45 to 0.66 kg/ac 1.2 to 1.6 L/ac	Apply PPI or PRE. S-metolachlor/benoxacor controls the grasses and atrazine controls the broadleaf weeds. When incorporated, s-metolachlor/benoxacor will control nutsedge for most of the season (10-14 weeks): mid season (July) germinating fall panicum may not be controlled. The high rate should be used where annual grass build up or nutsedge infestation is evident. The PPI application may not give full season control of fall panicum or velvetleaf.
simazine PRINCEP NINE-T (90WG) or simazine SIMADEX (500g/L) SIMAZINE 480 (480g/L) SIMAZINE 80W (80 WP)	1.35 to 2.25 kg/ha 1.5 to 2.5 kg/ha 1.6 to 4 kg/ha 3.2 to 8 L/ha 3.4 to 8.3 L/ha 2 to 2.75 kg/ha	 0.6 to 1 kg/ac 1.28 to 3.2 L/ac 1.36 to 3.32 L/ac 0.8 to 1.1 kg/ac	Apply PPI or PRE. These products are listed separately because of their widely differing rate ranges. In both cases the low rates should be used on sandy soils while the higher rates may be used on loams and clays. Full season annual weed control can be expected except for crabgrass or fall panicum where infestations have built up. Caution is advised when considering rates beyond 2.0 kg/ha (0.8 kg/ac) as soil residues may be high. Read "Notes on atrazine and simazine soil residues" at the start of the corn section. NOTE: Maximum registered Simazine 80W rate is 2.75 kg/ha (1.1 kg/ac) (2.2 kg/ha active).
Postemergent Grass Herbicides			
nicosulfuron ACCENT (75 DF) plus non-ionic surfactant CITOWETT PLUS, AGRAL 90 or AG-SURF	25 g/ha 33 g/ha 0.2 % v/v 2L/1000 L	 13 g/ac 0.2 % v/v 2L/1000 L	Always add water soluble packages to clean water with the agitator running. Corn should be within the 1 to 8 leaf stage of growth. Apply nicosulfuron when annual grasses are in the 1 to 6 leaf stage and/or quackgrass is in the 3 to 6 leaf stage (10 to 20 cm). DO NOT APPLY TO SEED CORN. DO NOT apply nicosulfuron to corn treated with organophosphorus insecticides. SWEET CORN - . Corn should be in the 1 to 6 leaf stage (4 visible collars). USE ONLY on these cultivars: Bonus BT, GSS 7831, CNS 710, Krispy King, GH 2690. DO NOT apply on Delmonte 2038.
s-metolachlor/benoxacor DUAL II MAGNUM (915g/L)	1.14 to 1.6 kg/ha 1.25 to 1.75 L/ha	 0.5 to 0.7 L/ac	Corn should be at the spike to 2 leaf stage and annual grasses not beyond 2 leaf stage. DO NOT add oil or surfactants.

Postemergent Broadleaf Herbicides

atrazine	1.01 kg/ha		This combination can be applied as a sequential treatment with a preemergent grass herbicide or in fields without grass infestation. Only escaping grasses up to the 3 leaf stage are suppressed with this combination.
ATRAZINE 480 (480g/L)	2.1 L/ha	0.84 L/ac	
AATREX NINE-O (90WG)	1.12 kg/ha	0.45 kg/ac	
plus pyridate	0.45 kg/ha		
LENTAGRAN (45 WP)	1 kg/ha	0.4 kg/ac	
atrazine	1.01 to 1.49 kg/ha		For increased activity and extended period of activity, apply in an oil water emulsion of 10 to 17 L/ha (4-6.8 L/ac) of emulsifiable light mineral oil and 150 to 200 L/ha water (60-80 L/ac). Apply when most weeds have emerged. The low rate can be used successfully with later cultivation.
ATRAZINE 480 (480g/L)	2.1 to 3.1 L/ha	0.84 to 1.24 L/ac	
ATRAZINE 90W (90WP)	1.12 to 1.65 kg/ha	0.45 to 0.66 kg/ac	
plus oil	10 to 17 L/ha	4 to 6.8 L/ac	
bentazon	0.841 to 1.082 kg/ha		No adjuvant is required to be used with BASAGRAN FORTE. Reduce oil concentrate to 1 L/ha (0.4 L/ac) under hot, humid weather conditions. Control is best when the broadleaves are small and actively growing. Grasses are NOT controlled. Top growth of nutsedge and Canada thistle are controlled and field bindweed may be suppressed by 2 applications of 1.75 L/ha (0.7 L/ac) (0.84 kg active/ha) applied 10 days apart. Cool weather or drought may delay control.
BASAGRAN FORTE (480g/L)	1.75 to 2.25 L/ha	0.7 to 0.9 L/ac	
or			
BASAGRAN (480g/L)	1.75 to 2.25 L/ha	0.7 to 0.9 L/ac	
plus oil concentrate			
ASSIST	2.L/ha	0.8 L/ac	
bentazon/ atrazine	0.8 to 1.6 kg/ha		The recommended rate of 1.2 to 1.6 kg/ha of bentazon/atrazine (3 to 4 L/ha (1.2 to 1.6 L/ac) LADDOK) may be reduced to 0.8 to 1 kg/ha (2 to 2.5 L/ha (0.8 to 1 L/ac) LADDOK) if metolachlor has been applied at the recommended rate for preemergence grass control. Use LADDOK at 3 to 4 L/ha (1.2 to 1.6 L/ac) for nutsedge control; repeat 7 to 10 days if necessary. Can be applied safely to all types and varieties of corn at any growth stage.
LADDOK ((1:1)400g/L)	2 to 4 L/ha	0.8 to 1.6 L/ac	
plus oil concentrate			
ASSIST	2 L/ha	0.8 L/ac	
bromoxynil	0.28 to 0.336 kg/ha		Controls most annual broadleaf weeds, including triazine resistant species at the 1 to 4 leaf stage. Bromoxynil is a contact herbicide and is non volatile.
PARDNER (280g/L)	1 to 1.2 L/ha	0.4 to 0.48 L/ac	

Postemergent Grass and Broadleaf Herbicides

cyanazine	2.25 kg/ha		Use only the dry flowable formulation, as the suspension may cause corn burning. DO NOT add oil or surfactants. DO NOT treat corn beyond the 3 leaf stage. Corn injury may occur during cold weather and under flooding conditions.
BLADEX 90 DF (90 DF)	2.5 kg/ha	1 kg/ac	
cyanazine	1.8 to 2.25 kg/ha		Use only the dry flowable formulation of cyanazine. Excellent control of annual weeds can be obtained if applied before grasses reach the 2 leaf stage. Use the low rate on coarse textured soils. DO NOT treat corn beyond the 3 leaf stage. Use this triazine mixture where barnyard grass may be a problem. DO NOT add oil or surfactants. Corn injury may occur during cold weather and under flooding conditions.
BLADEX 90 DF (90 DF)	2 to 2.5 kg/ha	0.8 to 1 kg/ac	
plus atrazine	1.1 kg/ha		
ATRAZINE 480 (480g/L)	2.25 L/ha	0.92 L/ac	
ATRAZINE 90W (90WP)	1.22 kg/ha	0.49 kg/ac	
AATREX NINE-O (90WG)	1.22 kg/ha	0.49 kg/ac	
metolachlor	1.92 to 2.64 kg/ha		Use only the dry flowable formulation of cyanazine. Apply the tank mix when corn is spike to 2 leaf and annual grasses are not beyond the 2 leaf stage. DO NOT add oil or surfactants. Corn injury may occur during cold weather and under flooding conditions.
DUAL (960 g/L)	2 to 2.75 L/ha	0.8 to 1.1 L/ac	
plus cyanazine	1.8 to 2.25 kg/ha		
BLADEX 90 DF (90 DF)	2 to 2.5 kg/ha	0.8 to 1 kg/ac	

Active Ingredient TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACR	PRECAUTIONS (For more information, see "Notes on Chemicals" section.)
nicosulfuron PARDNER.	25 g/ha		Use only when the corn is between the 4 and 8 leaf stage. See precautions for ACCENT and
ACCENT (75DF) plus bromoxynil PARDNER (280g/L) plus non-ionic surfactant	33 g/ha 0.28 kg/ha 1 L/ha 0.2% v/v	13 g/ac 0.4 L/ac 0.2% v/v	
s-metolachlor/benoxacor DUAL II MAGNUM (915g/L) plus atrazine ATRAZINE 480 (480g/L) AATREX NINE-O (90WG) or s-metolachlor/benoxacor/ atrazine PRIMEXTRA II MAGNUM ((1:0.8)720g/L)	1.14 to 1.6 kg/ha 1.25 to 1.75 L/ha 1.01 to 1.49 kg/ha 2.1 to 3.1 L/ha 1.12 to 1.65 kg/ha 2.16 to 2.88 kg/ha 3 to 4L/ha	 0.5 to 0.7 L/ac 0.84 to 1.24 L/ac 0.45 to 0.66 kg/ac 1.2 to 1.6 L/ac	High rates should be used for heavy grass infestation areas and for fall panicum control. Corn should be at the spike to 2 leaf stage. DO NOT add oil or surfactants to this mixture.
Directed Postemergence			
linuron AFOLAN F (480g/L) LOROX DF (50 DF) LINURON 480 (480g/L)	1.1 to 2.25 kg/ha 2.3 to 4.7 L/ha 2.2 to 4.5 kg/ha 2.4 to 4.5 L/ha	 0.92 to 1.88 L/ac 0.88 to 1.8 kg/ac 0.96 to 1.8 L/ac	Apply in oil water emulsion as directed spray at low pressure with drop nozzles after corn is 30 cm or more in height. The spray must be placed under the corn leaves but on the weeds. Use this treatment as a rescue from weeds escaping a previous treatment and for nutsedge or horsetail top growth burn. down DO NOT apply linuron after corn is beginning to tassel. Follow label directions carefully.
Spot Treatment			
glyphosate ROUNDUP TRANSORB (360g/L) GLYFOS (360 g/L) or glyphosate TMS TOUCHDOWN 480 (330g/L)	1.71 to 2.52 kg/ha 4.75 to 7 L/ha 4.75 to 7 L/ha 1.567 to 2.31 kg/ha 4.75 to 7 L/ha	 1.9 to 2.8 L/ac 1.9 to 2.8 L/ac 1.9 to 2.8 L/ac	DO NOT apply after corn has started to silk. Corn will be killed in the areas sprayed and may be damaged by spray drift in adjacent areas. Knapsack application of 100 mL ROUNDUP TRANSORB in 5 L of water applied to thoroughly wet the foliage, but not to runoff, is suggested for small areas to reduce drift and area of corn killed. Apply after Canada thistle has started flowering. Quackgrass should be actively growing.
glyphosate ROUNDUP TRANSORB (360g/L) GLYFOS (360 g/L) or glyphosate TMS TOUCHDOWN 480 (330g/L)	2.52 to 4.32 kg/ha 7 to 12 L/ha 7 to 12 L/ha 2.31 to 3.96 kg/ha 7 to 12 L/ha	 2.8 to 4.8 L/ac 2.8 to 4.8 L/ac 2.8 to 4.8 L/ac	DO NOT apply after corn has started to silk. Corn will be killed in the areas sprayed and may be damaged by spray drift in adjacent areas. Knapsack application of 100 mL ROUNDUP TRANSORB in 5 L of water applied to thoroughly wet the foliage, but not to runoff, is suggested for small areas to reduce drift and area of corn killed. Apply after field bindweed has reached full flowering, or milkweed has reached the bud stage. Quackgrass should be actively growing.

TABLE 6–11.
Sweet Corn Herbicide Weed Control Ratings

Note: Weed control ratings are given as 0–9, where 0 indicates no control, and 9 indicates 90–100% control under ideal conditions. Ratings are subjective values based on best available information and give general comparisons based on use as descibed in this guide. Under unfavourable conditions (e.g., too dry, too wet, too cold or poor application), the herbicides may not be as effective as indicated. Ratings may vary with weed and crop stage and with the timing and rates of the product(s) being used.

		Crop			Annual Grasses						Annual Broadleaves											Perennials						
Treatment	**Trade Name**	**seed corn**	**sweet corn**	**field corn**	**barnyard grass**	**crabgrass**	**fall panicum**	**foxtail**	**old witch grass**	**proso millet**	**buckwheat, wild**	**cocklebur**	**corn spurry**	**lady's thumb**	**lamb's-quarters**	**mustards**	**nightshades**	**pigweeds**	**ragweed**	**triazine resistant**	**velvetleaf**	**bindweed, field**	**horsetail**	**milkweed**	**nut sedge**	**quackgrass**	**sow-thistle**	**thistle, Canada**
Soil applied grass herbicides																											
dimethenamid	FRONTIER		✔	✔	**9**	**9**	**8/9[a]**	**9**	**9**	4	2	2	2	2	7	2	**8/9[b]**	**7/8**	5	7	3	0	0	0	**8/9[c]**	0	0	0
EPTC[+]	ERADICANE		✔	✔	**9**	**9**	**8**	**9**	**9**	7	2	4	**8**	7	**8**	2	8	**7**	7	7	4	2	7	0	**8[a]**	**2[a]**	2	2
s-metolachlor/ benoxacor	DUAL II MAGNUM	✔	✔	✔	**9**	**9**	**8/9[a]**	**9**	**9**	4	2	2	2	2	7	2	**8/9[b]**	**7/8**	5	7	3	0	0	0	**8/9[c]**	0	0	0
Soil applied broadleaf herbicides																											
atrazine	atrazine[d]	✔	✔	✔	7	4	4	7	7	2	**9**	7	**9**	**9**	**9**	9	9	**9**	**9**	0	5	2	0	0	0	2	2	0
simazine	PRINCEP NINE-T, SIMADEX, SIMAZINE 480	✔	✔	✔	**9**	**8**	7	**9**	**9**	2	**9**	7	9	**9**	**9**	9	9	9	**8**	0	5	2	0	0	5	5	2	2
Soil applied grass and broadleaf herbicides																											
cyanazine	BLADEX	✔	✔	✔	**7**	**9**	**8**	**9**	**9**	2	**8**	7	?	**8**	**9**	**9**	**9**	**7**	**8**	0	**5**	0	0	0	0	0	0	0
linuron	AFOLAN F		✔	✔	**7**	**7**	**7**	**7**	**7**	2	**9**	2	**?**	**9**	**9**	**9**	8	**9**	**8**	9	**2**	0	0	0	0	0	0	0
s-metolachlor/benoxacor/atrazine	PRIMEXTRA II MAGNUM	✔	✔	✔	**9**	**9**	**8/9[a]**	**9**	**9**	2	**9**	7	9	**9**	**9**	**9**	**9**	**9**	**9**	7	7	0	0	0	**8/9[c]**	0	0	0
Postemergent grass herbicides																											
nicosulfuron	ACCENT[e]		✔[e]	✔	**9**	5	**9**	**9**	**9**	**9**	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	**9**	0	0
s-metolachlor/ benoxacor	DUAL II MAGNUM	✔	✔	✔	**9**	**9**	**8/9[a]**	**9**	**9**	2	0	0	0	0	7	0	**8**	8	0	5	0	0	0	0	0	0	0	0
Postemergent broadleaf herbicides																											
atrazine + oil	atrazine[d] + oil	✔	✔	✔	7	2	0	7	7	2	**9**	7	9	**9**	**9**	**9**	9	**9**	**9**	0	7	7	5	2	5	5	7	2
atrazine + pyridate	atrazine[d] + LENTAGRAN	✔	✔	✔	7	0	?	7	?	?	**7**	?	?	**7**	**9**	**8**	**9**	**9**	**9**	9	**8**	?	?	?	?	?	?	?
bentazon	BASAGRAN FORTE	✔	✔	✔	0	0	0	0	0	0	7	**9**	**9**	**9**	**8**	**9**	7	**8**	**8**	**9**	**9**	**7**	0	0	**8**	0	**7**	**8**
bentazon/atrazine	LADDOK	✔	✔	✔	0	0	0	0	0	0	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	7	0	0	**8**	0	7	7
bromoxynil	PARDNER	✔	✔	✔	0	0	0	0	0	0	**9**	**8**	?	**9**	**9**	**8**	**9**	**8**	**9**	**9**	**9**	7	0	0	0	0	7	7
Postemergent grass and broadleaf herbicides																											
cyanazine	BLADEX	✔	✔	✔	**7**	**9**	**8**	**9**	**9**	5	**8**	8	?	**8**	**9**	9	**9**	**7**	**9**	0	8	2	2	0	0	0	2	2
s-metolachlor/benoxacor /atrazine	PRIMEXTRA II MAGNUM	✔	✔	✔	**9**	**9**	**8/9[a]**	**9**	**9**	2	**9**	7	**9**	**9**	**9**	**9**	**9**	**9**	**9**	7	7	0	0	0	3	0	0	0
Directed postemergence																											
linuron	AFOLAN F, LINURON 480, LOROX		✔	✔	**9**	**7**	**9**	**8**	**9**	8	**9**	9	**9**	**9**	**9**	**9**	9	**9**	**9**	9	**9**	7	**8**	7	**8**	7	8	7

? = Insufficient information available to make a rating.

Ratings in **BOLD** suggest the weed is listed on the product label for control or suppression. Please see product label for more information on registered weed species, product uses and precautions.

[a] Use the high rate of herbicide for optimum control.
[b] Use PRE timing for optimum control.
[c] Use PPI timing for optimum control.
[d] Various formulations available, see Table 6–2, *Pesticides Used on Vegetable Crops in Ontario*, on page 167.
[e] Use only on selected varieties. See precautions for tolerant varieties on label.

Sweet Potatoes

PREPLANT - See under PREPLANT - SITE PREPARATION for details of products, rates and remarks.

sethoxydim POAST ULTRA (450g/L) plus surfactant/solvent MERGE	0.15 to 0.2 kg/ha 0.32 to 0.47 L/ha 1.0 to 2.0 L/ha	 0.13 to 0.19 L/ac 0.4 to 0.8 L/ac	Apply sethoxydim to emerged grasses in the 1 to 6 leaf stage during active growth while the crop is small enough to permit thorough spray coverage. Complete control is normally obtained 7 to 21 days after treatment. Apply using 110 L/ha (44 L/ac) water.
sethoxydim POAST ULTRA (450g/L) plus surfactant/solvent MERGE	0.5 kg/ha 1.1 L/ha 1.0 to 2.0 L/ha	 0.45 L/ac 0.4 to 0.8 L/ac	Thorough preplant tillage will provide more uniform quackgrass emergence. Apply at the 1 to 3 leaf stage of actively growing quackgrass. Apply in 110 to 200 L/ha (44-80 L/ac) water. Use MERGE at a rate of 1% v/v. Crop competition inter-row cultivation 7 to 14 days after application will provide quackgrass control for 6 to 8 weeks.

Tomatoes (Transplanted)

All treatments should be applied in 150 to 300 L/ha (60-120 L/ac) water unless otherwise specified.

Weed control in tomatoes usually consists of a combination of chemical weed control and cultivation. Crop rotation is also beneficial in the control of weeds. Cultivation should be shallow to prevent bringing untreated soil to the surface which may result in another flush of weeds. When tomatoes are grown on raised beds and beds are reshaped during the course of the season, it may be necessary or useful to apply another herbicide treatment to areas between the rows to prevent a new weed infestation from interfering with harvesting. Do not exceed the total recommended rate per season of any herbicide applied more than once per year.

Band treatment of herbicides over the row will reduce the cost by one-half to two-thirds depending on the width of the band compared to the row spacing. Shallow inter-row cultivation will be required for weed control between the rows.

Perennial weeds may be partially controlled by cultivation. Controlling them in crops other than tomatoes when grown in rotation is the best approach to perennial weed control. Perennials are easily spread with cultivators or tillage equipment. Areas of perennial weeds are best tilled last. Machinery sanitation is important when moving from one field to another.

PREPLANT - See under PREPLANT - SITE PREPARATION for details of products, rates and remarks.

PREPLANT INCORPORATED - Two incorporations at right angles operating at a depth of 10 cm using a double disk (7-10 km/hour) or vibrating shank S-tine cultivator (10-13 km/hour) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness, and/or treating fields with perennial weeds last.

s-metolachlor DUAL MAGNUM (915g/L)	1.14 to 1.6 kg/ha 1.25 to 1.75 L/ha	 0.5 to 0.7 L/ac	Applied preplant followed by one incorporation with a double disk or vibrating shank (S-tine) cultivator operating at a depth of 10 cm. Lasts 10-14 weeks in the soil. Effective on most soils except high organic matter, muck or peat soils. Use only on transplant tomatoes grown for processing.
trifluralin TREFLAN (480g/L) RIVAL DF (60 DF) BONANZA 400 (400g/L)	0.6 to 1.105 kg/ha 1.25 to 2.3 L/ha 1 to 1.9 kg/ha 1.5 to 2.75 L/ha	 0.5 to 0.92 L/ac 0.4 to 0.76 kg/ac 0.6 to 1.1 L/ac	Incorporate twice in cross directions using a tandem disc (7-10 km/hr) or vibrating tine cultivator (10-13 km/hr) set to work 8-10 cm deep. The first incorporation should be done as soon as possible after application but may be delayed up to 8 to 24 hours. (See label.) The second incorporation is recommended anytime before planting. See "Notes on Chemicals" section for further details. Cool, wet weather may cause stunting of tomato transplants but yield is not usually affected.

Active Ingredient TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACRE	PRECAUTIONS (For more information, see "Notes on Chemicals" section.)
napropamide DEVRINOL DF (50 DF)	1.12 to 2.25 kg/ha 2.25 to 4.5 kg/ha	0.9 to 1.8 kg/ac	Use lower rates on lighter soils. Apply to well worked soil that is dry enough to permit thorough incorporation to a depth of 2.5 to 5.0 cm. Incorporate the same day as applied. After harvest, soil should be worked (across rows if banded) to prevent injury to succeeding crops. Small grains seeded in the fall may be stunted but not otherwise affected. Napropamide can be used on field seeded tomatoes. Consult product labels for more information.
s-metolachlor DUAL MAGNUM (915g/L) plus metribuzin SENCOR 500 F (500g/L)	1.14 to 1.6 kg/ha 1.25 to 1.75 L/ha 0.25 to 0.7 kg/ha 0.5 to 1.4 L/ha	0.5 to 0.7 L/ac 0.2 to 0.56 L/ac	See above recommendations for s-metolachlor. Consult the metribuzin label for additional instructions. Use lower rate of metribuzin for plug plants and repeat applications of metribuzin when crop is established as described under postemergence application of metribuzin. DO NOT exceed total maximum rate of metribuzin recommended for your soil type.
trifluralin TREFLAN (480g/L) plus metolachlor DUAL (960g/L) plus metribuzin SENCOR 500 F (500g/L)	0.528 to 1.008 kg/ha 1.1 to 2.1 L/ha 1.536 to 2.016 kg/ha 1.6 to 2.1 L/ha 0.25 to 0.5 kg/ha 0.5 to 1 L/ha	0.44 to 0.84 L/ac 0.64 to 0.84 L/ac 0.2 to 0.4 L/ac	Use the lower rates on lighter soils. Apply the spray solution and shallow incorporate (5 to 7.5 cm deep), then transplant 5-10 cm deep. Under cold, wet conditions on light textured soils there may be a delay in transplant establishment. Use only on transplant tomatoes grown for processing.
trifluralin TREFLAN (480g/L) RIVAL DF (60 DF) BONANZA 400 (400g/L) plus metribuzin SENCOR 500 F (500g/L) LEXONE DF (75 DF)	0.6 to 1.105 kg/ha 1.25 to 2.3 L/ha 1 to 1.9 kg/ha 1.5 to 2.75 L/ha 0.25 to 0.7 kg/ha 0.5 to 1.4 L/ha 0.32 to 0.93 kg/ha	 0.5 to 0.92 L/ac 0.4 to 0.76 kg/ac 0.6 to 1.1 L/ac 0.2 to 0.56 L/ac 0.13 to 0.37 kg/ac	Follow incorporation instructions as above for trifluralin. Use only for processing tomatoes. The lower rates are for sandy soils and higher rates for clay soils. Use lower rate of metribuzin for plug plants. See "Remarks" for metolachlor plus metribuzin.
Postemergent Grass Herbicides			
fenoxaprop-p-ethyl EXCEL SUPER (80.5g/L)	0.054 kg/ha 0.67 L/ha	0.27 L/ac	Apply to emerged grasses in the 1 to 6 leaf stage which are actively growing while crop is small enough to permit thorough coverage. A second application may be necessary to control grasses emerged after the first treatment. Fenoxaprop-p-ethyl can be used on field seeded tomatoes, consult product label for more information.
fluazifop-p-butyl FUSILADE II (125g/L)	0.075 to 0.25 kg/ha 0.6 to 2 L/ha	0.24 to 0.8 L/ac	Apply at 0.6 to 1 L/ha at 2 to 5 leaf stage of annual grasses. Apply at 1 to 2 L/ha at 3 to 5 leaf stage of quackgrass and wirestem muhly. Quackgrass top growth is suppressed at 1 L/ha. Thorough preplant tillage, fragmenting quackgrass rhizomes, improves control. Inter-row cultivation should not occur until 5 days after application. DO NOT tank mix with postemergence broadleaf weed herbicide. Apply other postemergence herbicides separately at least 3 days after fluazifop-p-butyl. Fluaziflo-p-butyl can be used on field seeded tomatoes. Consult product label for more information.
sethoxydim POAST ULTRA (450g/L) plus oil concentrate ASSIST or surfactant/solvent MERGE	0.15 to 0.2 kg/ha 0.32 to 0.47 L/ha 2 L/ha 1 L/ha	 0.13 to 0.19 L/ac 0.8 L/ac 0.4 L/ac	Tomatoes are tolerant to sethoxydim at any stage of growth. Apply sethoxydim to emerged grasses in the 1 to 6 leaf stage during active growth while crop is small enough to permit thorough spray coverage. Complete control is normally obtained 7 to 21 days after application. A second application may be necessary to control grasses that emerge after the first treatment. Water rates of 50 to 200 L/ha (20-80 L/ac) provide the best results. Sethoxydim can be used on field seeded tomatoes. Consult product label for more information.

sethoxydim POAST ULTRA (450g/L) plus oil concentrate ASSIST or surfactant/solvent MERGE	0.5 kg/ha 1.1 L/ha 4 L/ha 1 to 2 L/ha	 0.45 L/ac 1.6 L/ac 0.4 to 0.8 L/ac	Thorough preplant tillage will result in more uniform quackgrass emergence. Apply at 1 to 3 leaf stage of actively growing quackgrass in 110 to 200 L/ha (44-80 L/ac) water. Crop competition and inter-row cultivation 7 to 14 days after application will ensure quackgrass control for 6 to 8 weeks. Sethoxydim can be used on field seeded tomatoes. Consult product label for more information.
metribuzin LEXONE DF (75 DF) SENCOR 75 DF (75 WG)	0.25 to 0.85 kg/ha 0.32 to 1.1 kg/ha 0.32 to 1.1 kg/ha	 0.13 to 0.44 kg/ac 0.13 to 0.44 kg/ac	Use in processing tomatoes only. Apply before weeds exceed 5 cm in height. Direct spray to bottom one-third of tomato plants to reduce risk of crop injury. Apply 3 weeks after transplanting when tomato plants are established. Avoid application when crop is under stress due to cool, wet cloudy weather or excessively hot temperatures. Some tomato varieties are more sensitive than others. Use lower rates on sandy soils, higher rates on clay soils.
metribuzin SENCOR 500 F (500g/L) LEXONE DF (75 DF)	0.15 kg/ha 0.3 L/ha 0.2 kg/ha	 0.12 L/ac 0.08 kg/ac	Multiple application technique. One to four applications can be applied per season. Apply as a postemergence broadcast spray before the weeds are 4 cm high. Control of annual grasses may not be acceptable. Avoid application when crop is under stress due to cool, wet cloudy weather or excessively high temperatures as crop injury may result. DO NOT harvest within 30 days of application. The fungicide BRAVO 500(chlorothalanil) may be tank mixed with this treatment at the rate of 2.4 to 4.8 L/ha (1.2 to 2.4 kg/ha active). Please refer to the BRAVO 500 label for diseases controlled and specific recommendations.
pyridate LENTAGRAN (45 WP) plus metribuzin LEXONE DF (75 DF) SENCOR 75 DF (75 WG)	0.45 to 0.9 kg/ha 1 to 2.kg/ha 0.15 to 0.3 kg/ha 0.2 to 0.4 kg/ha 0.2 to 0.4 kg/ha	 0.4 to 0.8 kg/ac 0.08 to 0.16 kg/ac 0.08 to 0.16 kg/ac	Use trifluralin ppi and then apply pyridate + metribuzin to actively growing weeds as a directed spray to the bottom (1/3) one-third of well established tomato plants. DO NOT use before tomato plants reach the 5 leaf stage or if the plants are under stress. LENTAGRAN applied over tomato plants (not directed) will cause crop injury.
rimsulfuron PRISM (25DF) plus non-ionic surfactant	15 g/ha 60 g/ha 0.2 % v/v	 24 g/ac 0.2 % v/v	Add a non-ionic surfactant at 2L per 1000L spray solution (0.2 % v/v). Always add water soluble packages to clean water with the agitator running. Apply up to the 4 leaf stage of hairy nightshade. Apply when quackgrass is at the 3 to 6 leaf stage (less than 10 cm tall), annual grasses are at the 1 to 6 leaf stage and redroot pigweed is at the 4 to 6 leaf stage. DO NOT harvest crop within 30 days of treatment.

TABLE 6–12.

Vegetable Herbicide Weed Control Ratings

Note: Weed control ratings are given as 0–9, where 0 indicates no control, and 9 indicates 90–100% control under ideal conditions. Ratings are subjective values based on best available information and give general comparisons based on use as descibed in this guide. Under unfavourable conditions (e.g., too dry, too wet, too cold or poor application), the herbicides may not be as effective as indicated. Ratings may vary with weed and crop stage and with the timing and rates of the product(s) being used.

		Grasses					Annual Broadleaves								Perennials						
Treatment	Trade Name	barnyard grass	crabgrass	fall panicum	foxtails	old witch grass	buckwheat, wild	lady's thumb	lamb's-quarters	mustards	nightshades	pigweeds	ragweed	velvetleaf	bindweed, field	horsetail	milkweed	nut sedge	quackgrass	sow-thistle	thistle, Canada
Soil-applied grass herbicides																					
cycloate	RO-NEET	**8**	**8**	6	**8**	8	?	?	**7**	5	**7**	**8**	?	?	?	?	?	**6**	?	?	?
EPTC	EPTAM	**9**	**9**	**9**	**9**	**9**	6	7	**7**	5	8	**7**	5	5	?	?	?	**8**	**7**	?	?
napropamide	DEVRINOL	**8**	**9**	**8**	8	8	5	6	**8**	5	5	**8**	**7**	5	5	5	5	6	5	5	5
pendimethalin	PROWL	**9**	**8**	9	**8**	?	?	6	**9**	?	8	**8**	2	6	?	?	?	?	?	?	?
s-metolachlor	DUAL MAGNUM	**9**	**9**	**9**	**9**	**9**	2	2	7	2	**8**	**8**	3	2	0	0	0	**8**	4	0	0
triallate	AVADEX	5	?	?	5	5	5	5	5	5	?	5	5	?	5	?	?	?	?	5	5
Soil-applied broadleaf herbicides																					
linuron	LOROX, AFOLAN or LINURON 480	**7**	**5**	**5**	**7**	**7**	**8**	**9**	**9**	**9**	8	**9**	**8**	**6**	2	2	2	2	2	2	2
metobromuron	PATORAN	**5**	**5**	5	**5**	**5**	8	**9**	**9**	**9**	**7**	**9**	**8**	6	2	2	2	2	2	2	2
metribuzin	SENCOR, LEXONE	**7**	**6**	**7**	**8**	**8**	7	**9**	**9**	**9**	3	**9**	**8**	**8**	2	2	2	2	2	2	2
monolinuron	AFESIN	**5**	**5**	5	**5**	5	**8**	9	**9**	9	**7**	**9**	**8**	6	2	2	2	2	2	2	2
prometryne	GESAGARD	?	?	?	**9**	?	?	**8**	**9**	**8**	**8**	**8**	6	?	?	?	?	?	?	?	?
pyrazon	PYRAMIN	**5**	**5**	5	**5**	5	**8**	**8**	**8**	8	**8**	**8**	**8**	6	5	5	?	5	5	5	5
Soil-applied grass and broadleaf herbicides																					
diuron	KARMEX	9	**8**	7	**8**	?	8	8	**9**	8	7	**8**	**9**	?	?	5	?	5	5	5	5
terbacil	SINBAR	**8**	**7**	8	**8**	8	?	7	**8**	**8**	7	**7**	**7**	7	?	5	6	6	6	?	6
chlorpropham	CIPC	8	9	7	8	7	8	8	7	5	?	7	5	?	?	5	?	?	5	5	5
ethofumesate	NORTRON SC	**7**	**6**	7	**7**	7	**8**	**8**	**8**	8	**7**	**8**	8	7	5	5	5	6	5	5	5
imazethapyr	PURSUIT	**8**	7	7	**9**	9	8	**9**	**9**	**9**	**9**	**9**	**8**	**9**	?	?	?	7	5	?	?
naptalam	ALANAP	5	7	5	7	?	5	9	9	6	5	8	5	?	?	5	?	5	5	5	5
propyzamide	KERB	**8**	**8**	**8**	**8**	**8**	?	6	6	7	7	0	0	0	0	0	0	0	0	0	0
simazine	PRINCEP-NINE-T	**9**	**8**	7	**9**	**9**	**9**	**9**	**9**	9	9	9	**8**	5	2	0	0	5	5	2	2
trifluralin	TREFLAN or RIVAL or BONANZA 400	**9**	**9**	9	**9**	9	**6**	7	**8**	2	2	**8**	4	2	2	2	2	2	2	2	2
Postemergence grass herbicides																					
propyzamide	KERB	**8**	**8**	**6**	**8**	?	?	0	0	0	?	6	0	0	0	0	0	0	**8**	0	0
clethodim	SELECT	**9**	**8**	**9**	**8**	**9**	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0
diclofop-methyl	HOE-GRASS 284	**8**	5	8	**8**	8	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
fenoxaprop-p-ethyl	EXCEL SUPER	**9**	**8**	**9**	**9**	**9**	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
fluazifop-p-butyl	FUSILADE II	**8**	**8**	**9**	**8**	**9**	0	0	0	0	0	0	0	0	0	0	0	0	**8**	0	0
rimsulfuron	PRISM	**9**	8	**9**	**8**[a]	**9**	?	7	**7**	9	4	**9**	3	6	?	?	?	?	**7**	?	?
sethoxydim	POAST ULTRA	**9**	**8**	**9**	**9**	**9**	0	0	0	0	0	0	0	0	0	0	0	0	**6**	0	0

TABLE 6–12.
Vegetable Herbicide Weed Control Ratings (Continued)

Note: Weed control ratings are given as 0–9, where 0 indicates no control, and 9 indicates 90–100% control under ideal conditions. Ratings are subjective values based on best available information and give general comparisons based on use as descibed in this guide. Under unfavourable conditions (e.g., too dry, too wet, too cold or poor application), the herbicides may not be as effective as indicated. Ratings may vary with weed and crop stage and with the timing and rates of the product(s) being used.

		Grasses					**Annual Broadleaves**								**Perennials**						
Treatment	**Trade Name**	**barnyard grass**	**crabgrass**	**fall panicum**	**foxtails**	**old witch grass**	**buckwheat, wild**	**lady's thumb**	**lamb's-quarters**	**mustards**	**nightshades**	**pigweeds**	**ragweed**	**velvetleaf**	**bindweed, field**	**horsetail**	**milkweed**	**nut sedge**	**quackgrass**	**sow-thistle**	**thistle, Canada**
Postemergence broadleaf herbicides																					
2,4-D[b]		0	0	0	0	0	7	**7**	**9**	**9**	7	**9**	**9**	9	**7**	**0**	0	0	0	**8**	**8**
bentazon	BASAGRAN FORTE	0	0	0	0	0	8	**9**	**8**	**9**	7	**8**	**8**	**9**	5[c]	2	2	**8**[c]	0	**6**[c]	**7**[c]
bromoxynil	PARDNER	0	0	0	0	0	**9**	**9**	**9**	**8**	**9**	**8**	**9**	**9**	7	0	0	0	0	7	7
clopyralid	LONTREL	5	5	5	5	5	**?**	7	5	?	5	5	**8**	5	5	?	?	5	5	**7**	**7**
desmedipham	BETANEX	5	5	5	5	5	**5**	6	**7**	**7**	**6**	**9**	**9**	5	5	?	?	5	5	5	5
desmedipham + phenmedipham	BETAMIX	5	5	5	**7**	5	**6**	6	**8**	**7**	**6**	**8**	**8**	5	5	?	?	5	5	5	5
herbicidal oil[b]		?	?	?	?	?	?	6	7	7	?	7	5	?	5	5	5	5	5	5	5
MCPA[b]		0	0	0	0	0	**4**	0	**9**	**9**	?	**9**	**8**	**9**	7	**7**	0	0	0	**7**	**7**
oxyfluorfen	GOAL 2XL	5	5	5	5	5	**9**	8	**8**	9	**9**	**9**	8	7	5	5	5	5	5	5	5
pyrazon	PYRAMIN	**5**	5	?	5	?	**8**	**8**	**8**	**8**	**8**	**8**	**8**	?	?	5	?	5	5	5	5
pyridate	LENTAGRAN	?	?	?	?	?	?	?	**8**	?	?	**8**	?	?	?	?	?	?	?	?	?
Postemergence grass and broadleaf herbicides																					
linuron	LOROX, AFOLAN or LINURON 480	**9**	**7**	9	**8**	**9**	**8**	**8**	**8**	8	8	**8**	**8**	**8**	7	8	7	8	7	8	7
metribuzin	SENCOR or LEXONE	**8**	**7**	**9**	**8**	**9**	**7**	**9**	**8**	**9**	?	**8**	**8**	**8**	?	?	?	?	7	?	?
phenmedipham	SPIN-AID	5	5	5	**6**	5	?	8	**8**	**?**	7	6	8	7	5	5	5	5	5	5	5
Post (Directed)																					
pyridate + metribuzin	LENTAGRAN + SENCOR or LEXONE	6	5	?	6	?	**7**	**7**	**9**	**8**	**9**	**9**	**9**	**8**	5	5	5	5	5	5	5
Preharvest																					
glufosinate ammonium	IGNITE	9	9	9	**9**	9	**?**	9	**9**	**9**	?	**9**	9	9	8[d]	7[d]	6[d]	0	8[d]	?	?

? = Insufficient information available to make a rating.

Ratings in **BOLD** suggest the weed is listed on the product label for control or suppression. Please see product label for more information on registered weed species, product uses and precautions.

[a] Yellow foxtail will only be suppressed.

[b] Various formulations available, see Table 6–2, *Pesticides Used on Vegetable Crops in Ontario*, on page 167.

[c] Good control of these perennial weeds may require two applications of BASAGRAN + ASSIST oil concentrate about 7 to 10 days apart.

[d] Repeated applications may be necessary if regrowth occurs.

Active Ingredient TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACRE	PRECAUTIONS (For more information, see "Notes on Chemicals" section.)
Special Methods Of Weed Control - Preplant-Site Preparation			
amitrole AMITROL 240 (231g/L)	1 to 2 kg/ha 4.2 to 8.4 L/ha	1.68 to 3.36 L/ac	Apply in 100-200 L/ha water (40-180 L/ac) 10-14 days before planting the crop. Soybeans may be planted 6 days after application when applied at the low rate. Use additional herbicide treatments to control weed species that emerge after amitrole application. Amitrole will not provide residual weed control.
amitrole AMITROL 240 (231g/L)	3 to 4 kg/ha 12.5 to 16.5 L/ha	5 to 6.6 L/ac	ONLY FOR USE BEFORE WHITE BEANS, CORN AND SOYBEANS. Apply to actively weeds up to 10 cm tall and Canada thistle in the fall or spring. Plow or thoroughly disk 10-14 days after application. Cultivation may be required when the crop is emerged.
glyphosate ROUNDUP TRANSORB (360g/L) GLYFOS (360g/L) or glyphosate TMS TOUCHDOWN 480 (330g/L)	0.27 to 1.26 kg/ha 0.75 to 3.5 L/ha 0.75 to 3.5 L/ha 0.249 to 1.155 kg/ha 0.75 to 3.5 L/ha	0.3 to 1.4 L/ac 0.3 to 1.4 L/ac 0.3 to 1.4 L/ac	See the product labels for specific details. Glyphosate can be applied to actively growing weeds in the fall, or spring prior to emergence of any crop. Only weeds emerged at application time will be controlled. Additional weed control programs will be necessary to control weeds germinating later. Refer to the product label for specific rates for annual weeds. The low rate must be applied 50 to 100 L/ha water (20-40 L/ac). Apply the low rate plus a surfactant if greater volumes of water are used. Higher rates may be applied in 100 to 300 L/ha water (40-120 L/ac).
glyphosate ROUNDUP TRANSORB (360g/L) GLYFOS (360g/L) or glyphosate TMS TOUCHDOWN 480 (330g/L)	0.9 to 2.52 kg/ha 2.5 to 7 L/ha 2.5 to 7 L/ha 0.825 to 2.31 kg/ha 2.5 to 7 L/ha	1 to 2.8 L/ac 1 to 2.8 L/ac 1 to 2.8 L/ac	For perennial grass control apply to actively growing plants with at least 3-4 new leaves. The low rate (2.5 L/ha (1 L/ac)) will provide a minimum of one season control while higher rates (4.75 to 7 L/ha (1.9 to 2.8 L/ac)) will provide longer term control. For dandelion control apply 2.5 L/ha (1 L/ac) if 15 cm or less in diameter and 3.5 to 5 L/ha (1.4 to 2 L/ac) if larger than 15 cm.
glyphosate ROUNDUP TRANSORB (360g/L) GLYFOS (360g/L) or glyphosate TMS TOUCHDOWN 480 (330g/L)	2.52 to 4.32 kg/ha 7 to 12 L/ha 7 to 12 L/ha 2.31 to 3.96 kg/ha 7 to 12 L/ha	2.8 to 4.8 L/ac 2.8 to 4.8 L/ac 2.8 to 4.8 L/ac	Canada thistle and sow-thistle should be at least in early bud, milkweed at bud, bindweed at full flower, and dogbane past full bloom for best results. All species should be actively growing at application time. Allow 5 to 7 days translocation time after application before doing any tillage when conditions are good. If cool temperatures follow application, allow additional time for translocation to be completed before disturbing treated weeds. Use the higher rate for best control of solid stands of undisturbed perennials such as sod in non-crop areas. Repeat application to regrowth may be necessary for complete control.
glyphosate/glufosinate ammonium ROUNDUP FASTFORWARD PRESEED ((30:1) 310g/L)	0.465 to 1.302 kg/ha 1.5 to 4.2 L/ha	0.6 to 1.7 L/ac	0.6 L/ac is recommended mainly for annual grass weeds up to 15 cm in height. 1.1 L/ac is recommended for annual grass and broadleaf weeds up to 15 cm in height. 1.7 L/ac is recommended for annual weeds over 15 cm in height. See label for more details.
glyphosate/glufosinate ammonium ROUNDUP FASTFORWARD PRESEED ((30:1) 310g/L)	0.93 to 2.604 kg/ha 3.0 to 8.4 L/ha	1.2 to 3.4 L/ac	Use the higher rates for heavier infestations and for dandelions larger than 15 cm. 1.5 L/ac and 2 L/ac are recommended for average quackgrass and dandelion infestations respectively.
paraquat GRAMOXONE (200g/L)	0.55 to 1.1 kg/ha 2.75 to 5.5 L/ha	1.1 to 2.2 L/ac	Apply paraquat to actively growing vegetation at least 3 days prior to crop emergence. Use the high rate when weeds are above 5 cm in height. Apply paraquat in 300 to 1100 L/ha water (120-440 L/ac). Complete coverage is important. Use higher water volumes on dense vegetation. Perennial weeds will only be suppressed. Only emerged weeds will be controlled.

glufosinate ammonium IGNITE (150g/L)	0.405 to 0.75 kg/ha 2.7 to 5 L/ha	 1.08 to 2 L/ac	Apply in a minimum of 110-330 L/ha (44-132 L/ac) of water in carrot, lettuce and onion crops only. IGNITE may be applied as a stale seedbed technique prior to emergence of the crop. See label for more detailed information.
glyphosate ROUNDUP TRANSORB (360g/L) plus surfactant AGRAL 90, AGSURF, ENHANCE	0.27 to 1.26 kg/ha 0.75 to 3.5 L/ha 0.35 L/ha	 0.3 to 1.4 L/ac 0.14 L/ac	Till and fertilize soil in early spring. Allow weeds to grow. Spray weeds just before seeding crop. Use low rate for small weeds (8 cm), medium rates for weeds 8 to 15 cm and higher rate for weeds over 15 cm tall. Apply recommended preemergence or postemergence herbicides to control new flushes of weeds or use mechanical means of control.
glyphosate/glufosinate ammonium ROUNDUP FASTFORWARD PRESEED ((30:1) 310g/L)	0.465 to 1.302 kg/ha 1.5 to 4.2 L/ha	 0.6 to 1.7 L/ac	0.6 L/ac is recommended mainly for annual grass weeds up to 15 cm in height. 1.1 L/ac is recommended for annual grass and broadleaf weeds up to 15 cm in height. 1.7 L/ac is recommended for annual weeds over 15 cm in height. See label for more details.
glyphosate/glufosinate ammonium ROUNDUP FASTFORWARD PRESEED ((30:1) 310g/L)	0.93 to 2.604 kg/ha 3.0 to 8.4 L/ha	 1.2 to 3.4 L/ac	Use the higher rates for heavier infestations and for dandelions larger than 15 cm. 1.5 L/ac and 2 L/ac are recommended for average quackgrass and dandelion infestations respectively.
paraquat GRAMOXONE (200g/L) or diquat REGLONE (200g/L)	0.6 to 1.1 kg/ha 3 to 5.5 L/ha 0.6 to 1.1 kg/ha 3 to 5.5 L/ha	 1.2 to 2.2 L/ac 1.2 to 2.2 L/ac	One of these herbicides may be used to kill emerged weeds on a prepared seedbed before the crop seed is sown. Check label for list of crops for which this technique is registered. In inter-row weeding, special low pressure equipment is used to apply the herbicide on emerged weeds without contact with leaves of the crop plants. For small areas, apply 30 mL product in 10 L water per 100 m2.
paraquat/ diquat C.I.L.WEED & GRASS KILLER WEED-BAN	See Label		DOMESTIC - Soluble granular formulations for home garden use. Check label for rates.

Post Harvest

2,4-D ESTASOL (564g/L) ESTER 600 (564g/L) ESTER 700 (660g/L)	0.85 to 1.555 kg/ha 1.5 to 2.75 L/ha 1.5 to 2.75 L/ha 1.29 to 2.36 L/ha	 0.6 to 1.1 L/ac 0.6 to 1.1 L/ac 0.52 to 0.94 L/ac	Apply in the fall at the time of rapid growth. Use the higher rate for legumes and perennial weeds. For best results apply to actively growing vegetation at least 2 weeks before a killing frost. DO NOT apply before fall wheat or barley.
2,4-D/ dicamba/ mecoprop KIL-MOR (485g/L)	0.534 to 0.849 kg/ha 1.1 to 1.75 L/ha	 0.44 to 0.7 L/ac	Ground application only. DO NOT apply if wind velocity exceeds 8 km/hr. Apply in 200 L/ha water (80 L/ac).
dicamba BANVEL II (480g/L)	1.2 kg/ha 2.5 L/ha	 1 L/ac	Apply in the fall to actively growing vegetation at least 2 weeks prior to a killing frost. DO NOT apply before fall seeded crops. Grow only cereals, soybeans, field corn, sweet corn or white beans the year after application of BANVEL II at 2.5 L/ha (1 L/ac). Refer to "Notes on Chemicals" and product label for registered rates of BANVEL II, surfactants tank mixes and appropriate water volumes.

Active Ingredient TRADE NAME (Formulation)	RATE (active) PRODUCT PER HA	RATE PRODUCT PER ACRE	PRECAUTIONS (For more information, see "Notes on Chemicals" section.)
amitrole AMITROL 240 (231g/L)	3 to 4 kg/ha 12.5 to 16.5 L/ha	5 to 6.6 L/ac	Apply after harvest when regrowth is 10 to 15 cm tall for Canada thistle and sowthisle. Allow 2 weeks before working (cultivation). DO NOT apply after a heavy frost, generally after Oct. 1. DO NOT plant to a crop for 8 months after treatment.
dicamba BANVEL II (480g/L) plus glyphosate ROUNDUP (356g/L) plus non-ionic surfactant	0.6 kg/ha 1.25 L/ha 0.6 kg/ha 1.7 L/ha 0.35 L/ha	0.5 L/ac 0.68 L/ac 0.14 L/ac	Apply in the fall to actively growing vegetation at least 2 weeks prior to a killing frost. DO NOT apply before fall seeded crops. Grow only cereals, soybeans, field corn, sweet corn or white beans the year after application of BANVEL II at 2.5 L/ha (1 L/ac). Refer to "Notes on Chemicals" and product label for registered rates of BANVEL II, surfactants, tank mixes and appropriate water volumes.
glyphosate ROUNDUP TRANSORB (360g/L) GLYFOS (360g/L) or glyphosate TMS TOUCHDOWN 480 (330g/L)	0.9 to 2.52 kg/ha 2.5 to 7 L/ha 2.5 to 7 L/ha 0.825 to 2.31 kg/ha 2.5 to 7 L/ha	1 to 2.8 L/ac 1 to 2.8 L/ac 1 to 2.8 L/ac	For perennial grass control apply to actively growing plants with at least 3-4 new leaves. The low rate (2.5 L/ha (1 L/ac)) will provide a minimum of one season control while higher rates (4.75 to 7 L/ha (1.9 to 2.8 L/ac)) will provide longer term control. For dandelion control apply 2.5 L/ha (1 L/ac) if 15cm or less in diameter and 3.5 to 5 L/ha (1.4 to 2 L/ac) if larger than 15 cm.
glyphosate ROUNDUP TRANSORB (360g/L) GLYFOS (360g/L) or glyphosate TMS TOUCHDOWN 480 (330g/L)	2.52 to 4.32 kg/ha 7 to 12 L/ha 7 to 12 L/ha 2.31 to 3.96 kg/ha 7 to 12 L/ha	2.8 to 4.8 L/ac 2.8 to 4.8 L/ac 2.8 to 4.8 L/ac	Apply when regrowth is at least 20-25 cm tall or in the bud to bloom stage. The more growth present the better the results. Use higher rates for heavy infestations.
Spot Treatment			
Hand Held Equipment For Selective Weed Control			
amitrole AMITROL 240 (231g/L)	3 to 4 kg/ha 12.5 to 16.5 L/ha	5 to 6.6 L/ac	REGISTERED FOR NON-CROP LAND AND PASTURE. Thoroughly wet all leaves and stems of weeds. Refer to label for appropriate stage of weed growth. Repeat applications when new growth appears. DO NOT let livestock eat treated vegetation. Keep livestock off treated area until weeds are dead and new growth has emerged.
glyphosate EXPEDITE GRASS & WEED (147g/L)	0.88 to 1.25 kg/ha 6 to 8.5 L/ha	2.4 to 3.4 L/ac	EXPEDITE herbicides are ready-to-use products which must be applied with the EXPEDITE application system. This low volume application should not be applied "spray to wet" or runoff. Material should be calibrated for proper use rate prior to application. Consult label for calibration and application instructions.
glyphosate EXPEDITE GRASS & WEED (147g/L)	1.25 to 2.5 kg/ha 8.5 to 17 L/ha	3.4 to 6.8 L/ac	EXPEDITE herbicides are ready-to-use products which must be applied with the EXPEDITE application system. This low volume application should not be applied "spray to wet" or runoff. Material should be calibrated for proper use rate prior to application. Consult label for calibration and application instructions.

glyphosate EXPEDITE GRASS & WEED (147g/L)	2.5 to 4.265 kg/ha 17 to 29 L/ha	6.8 to 11.6 L/ac	EXPEDITE herbicides are ready-to-use products which must be applied with the EXPEDITE application system. This low volume application should not be applied "spray to wet" or runoff. Material should be calibrated for proper use rate prior to application. Consult label for calibration and application instructions.
glyphosate ROUNDUP TRANSORB (360g/L) GLYFOS (360g/L) or glyphosate TMS TOUCHDOWN 480 (330g/L)	0.36 kg/100L 1 L/100L 1 L/100L 0.33 kg/100L 1 L/100L		See label for appropriate stage of weed development and for a list of crops for which this technique is registered.
glyphosate ROUNDUP TRANSORB (360g/L) GLYFOS (360g/L) or glyphosate TMS TOUCHDOWN 480 (330g/L)	0.72 kg/100L 2 L/100L 2 L/100L 0.66 kg/100L 2 L/100L		See label for appropriate stage of weed development and for a list of crops for which this technique is registered.
glyphosate ROUNDUP TRANSORB (360g/L) GLYFOS (360g/L) or glyphosate TMS TOUCHDOWN 480 (330g/L)	0.36 kg/2L water 1 L/2L water 1 L/2L water 0.33 kg/2L water 1 L/2L water		Apply to weeds which extend above the crop sufficiently to allow good contact with the application equipment. Be careful not to contact the crop with the equipment to allow the chemical solution to drip from the applicator on to the crop. A 33% herbicide mixture (1 L to 2 L of water) provides good control of most weeds.

TABLE 6–13.
Post Harvest Weed Control

Note: Weed control ratings are given as 0–9, where 0 indicates no control, and 9 indicates 90–100% control under ideal conditions. Ratings are subjective values based on best available information and give general comparisons based on use as descibed in this guide. Under unfavourable conditions (e.g., too dry, too wet, too cold or poor application), the herbicides may not be as effective as indicated. Ratings may vary with weed and crop stage and with the timing and rates of the product(s) being used.

		Grasses		Perennial Broadleaf Weeds								
Crop Stubble	**Treatment**	**quackgrass**	**wire-stemmed muhly**	**field bindweed**	**chickweed, mouse-eared**	**colt's-foot**	**dandelion**	**hemp dogbane**	**milkweed**	**ground cherry**	**Canada thistle**	**sow thistle**
Post harvest herbicides												
glyphosate	GLYPHOS, ROUNDUP, TOUCHDOWN	**9**	**9**	**9**	**9**	**8**	**8/9[a]**	**8**	**8**	?	**9**	**9**
dicamba	BANVEL II	0	0	**8**	9	7	8	8	7	6	**8**	**9**
2,4-D/ mecoprop/ dicamba	KILMOR	0	0	**8**	9	?	8	2	0	?	**7**	8
2,4-D	2,4-D[b]	0	0	**7**	2	?	**7**	?	0	?	**6**	**7**

? = Insufficient information available to make a rating.

Ratings in **BOLD** suggest the weed is listed on the product label for control or suppression. Please see product label for more information on registered weed species, product uses and precautions.

[a] Use higher rates for weeds larger than 15 cm tall or across.

[b] Various products available. See Table 6–2, *Pesticides Used on Vegetable Crops in Ontario*, on page 167.

7. Appendices

APPENDIX A.
Ontario Ministry of the Environment Pesticides Control Offices

Region/County	Pesticides Officer Address	Telephone/Fax	
Central Region Toronto, Halton, Peel, York, Durham	Charles Zubovits 5775 Yonge Street, 8th Floor Toronto, Ontario M2M 4J1	Tel Toll Free Fax	(416) 326-3671 1-800-810-8048 (416) 325-6347
West-Central Region Haldimand-Norfolk, Niagara, Hamilton-Wentworth, Dufferin, Wellington, Waterloo, Brant	Paul McCubbin Linda Dennie Ontario Government Building 119 King Street West, 12th Floor Hamilton, Ontario L8N 3Z9	Tel Fax	(905) 521-7667 (905) 521-7658 (905) 521-7820
Eastern Region Frontenac, Hastings, Lennox & Addington, Prince Edward, Leeds & Grenville, Prescott & Russell, Stormont/Dundas & Glengarry, Peterborough, Victoria, Northumberland, Renfrew, Ottawa-Carleton, Lanark, District of Nipissing (Townships of Airy, Murchison, Dickens, Lyell and Sabine)	Andrew Morley 133 Dalton Avenue Kingston, Ontario K7L 4X6	Tel Fax Toll Free	(613) 549-4000, x 2684 (613) 548-6908 1-800-267-0974
Southwestern Region Elgin, Middlesex, Oxford, Essex, Kent, Lambton, Bruce, Grey, Huron, Perth,Simcoe	Doug Morrow Wray Lampman 659 Exeter Road, 2nd Floor London, Ontario N6E 1L3	Tel Fax	(519) 873-5047 (519) 873-5048 (519) 873-5000
Northern Region Manitoulin, Nipissing, Parry Sound, Sudbury, Algoma East, Cochrane East, Haliburton, Muskoka, Kenora, Rainy River, Thunder Bay, Algoma West, Cochrane West	Ray Potvin John Negusanti 199 Larch Street, Suite 1101 Sudbury, Ontario P3E 5P9	Tel Fax	(705) 564-3247 (705) 564-3249 (705) 564-4180
Standards Development Branch	Pesticides Section (Mailing Address) 135 St. Clair Avenue West Toronto, Ontario M4V 1P5	Tel Fax	(416) 327-5519 (416) 327-2936
Approvals Branch	Pesticides Licensing 250 Davisville Avenue, 3rd Floor Toronto, Ontario M4S 1H2	Tel Toll Free Fax	(416) 440-3584 1-800-461-6290 (416) 440-6973

APPENDIX B.
Accredited Soil Testing Laboratories in Ontario

The following labs are accredited to perform soil tests for pH, buffer pH, P, K, Mg and Nitrate-N on Ontario soils.

A & L Canada Laboratories East, Inc.
2136 Jetstream Road
London, Ontario N5V 3P5
Tel (519) 457-2575
Fax (519) 457-2664
web site www.al-labs-can.com
email aginfo@al-labs-can.com
Contact Mr. Greg Patterson
Mr. Ian McLachlin

Accutest Laboratories
146 Colonnade Road, Unit #8
Nepean, Ontario K2E 7Y1
Tel (613) 727-5692
Fax (613) 727-5222
web site www.accutestlabs.com
email phaulena@accutestlabs.com
Contact Mrs. Lorna Wilson
Mr. Peter Haulena

Agri-Food Laboratories
503 Imperial Road, Unit #1
Guelph, Ontario N1H 6T9
Tel (519) 837-1600, 1-800-265-7175
Fax (519) 837-1242
web site: www.agtest.com
email lab@agtest.com
Contact Mr. Dale Cowan
Ms. Nora Wilson

Soil and Nutrient Laboratory
(formerly Analytical Services, Land Resource Science)
University of Guelph
P.O. Box 3650, 95 Stone Road West
Guelph, Ontario N1H 8J7
Tel (519) 767-6226
Fax (519) 767-6240
email vkerslak@lsd.uoguelph.ca

Stratford Agri Analysis Inc.
(A Daco Laboratories Ltd. company)
1131 Erie Street, Box 760
Stratford, Ontario N5A 6W1
Tel (519) 273-4411, 1-800-323-9089
Fax (519) 273-4411
email saa@dacolabs.com
Contact Mr. Dale Peters
Mr. Gary Roberts
Mr. Keith Lemp

APPENDIX C.
Other Contacts

Agriculture & Agri-Food Canada Research Centres
Eastern Cereals and Oilseeds Research Centre
960 Carling Avenue
Ottawa, K1A 0C6
Tel (613) 759-1952

Greenhouse and Processing Crops Centre
Harrow N0R 1G0
Tel (519) 738-2251

Southern Crop Protection and Food Research Centre
1391 Sandford Street
London N5V 4T3
Tel (519) 457-1470

Vineland Research Farm
4902 Victoria Avenue North
Vineland L0R 2E0
Tel (905) 562-4113

Delhi Research Farm
Box 186 Schafer Road
Delhi N4B 2W9
Tel (519) 582-1950

Horticultural Research & Development Centre
430 Boul. Gouin
St. Jean sur Richelieu, Quebec
J3B 3E6
Tel (450) 346-4494

Canadian Food Inspection Agency Regional Offices (Plant Protection)
Belleville
345 College Street East
Belleville, K8N 5S7
Tel (613) 969-3333

Brantford
Federal Building, Dalhousie & Queen St., P.O. Box 637
Brantford, N3T 5P9
Tel (519) 751-8157

Hamilton
709 Main Street West, Suite 101
Hamilton, L8S 1A2
Tel (905) 572-4152

London
457 Richmond Street, Suite 404
London, N6A 3E3
Tel (519) 645-4021

Niagara Falls
Mailing address: P.O. Box 35, Niagara Falls, L2E 6S8
Street address: 4551 Zimmerman Avenue
Niagara Falls, L2E 3M5
Tel (905) 357-5981

Ottawa District
3 Observatory Crescent
Building #3 Central, Experimental Farm
Ottawa, K1A 0C9
Tel (613) 759-1571

Toronto
401 Champagne Drive, Unit 1
Downsview, M3J 2C6
Tel (416) 954-1714

Windsor
441 University Avenue West, Suite 208
Windsor, N9A 5P9
Tel (519) 252-7095

University of Guelph
Main Campus
Guelph, N1G 2W1
Tel (519) 824-4120

Alfred College
Alfred, K0B 1A0
Tel (613) 679-2218

Kemptville College
Kemptville, K0G 1J0
Tel (613) 258-8336
Ridgetown College
Ridgetown, N0P 2C0
Tel (519) 674-1500

Department of Plant Agriculture, Kettleby
1125 Woodchopper's Lane, R.R. # 1
Kettleby, L0G 1J0
Tel (905) 775-3783

Department of Plant Agriculture, Simcoe
Box 587 Blue Line Road
Simcoe, N3Y 4N5
Tel (519) 426-7127

Department of Plant Agriculture, Simcoe
Box 7000, 4890 Victoria Avenue North
Vineland Station, L0R 2E0
Tel (905) 562-4141

Lab Services Division
Pesticide and Trace Contaminants
P.O. Box 3650, 95 Stone Road West
Guelph, N1H 8J7
Tel (519) 767-6200

Pest Diagnostic Clinic
Tel (519) 767-6256

APPENDIX D.
Crop Insurance

The Canada-Ontario Crop Insurance Program is publicly funded by the Canadian and Ontario governments, and delivered by AGRICORP. The federal and provincial governments each contribute 25% of the premium cost and 50% of the administrative costs. Both these contributions enable an Ontario grower to purchase insurance coverage at a substantially reduced cost.

The grower's payment is considered an operating expense for income tax purposes. Crop insurance offers protection against a broad range of production hazards, including excessive rain, hail, excessive drought, freeze, frost, excessive wind and certain insects and diseases.

For further information, contact your Territory Sales Manager or:

AGRICORP
1 Stone Road West
Box 3660, Station Central
Guelph, ON N1H 8M4
(519) 826-3276
1-888-247-4999
www.AGRICORP.com

Ontario Crops Covered by a Crop Insurance Plan

Fruit Crops	Vegetables	General Crops	Tobacco
Apples (fruit and/or trees)	Asparagus	Beans, coloured	Black
Cherries, sweet and sour	Beans (green and wax, processing only)	Beans, white	Flue-cured
Grapes (fruit and/or vines)	Beets (processing only)	Canola	
Peaches (including nectarines)	Broccoli	Corn (grain and silage)	
Pears	Cabbage	Corn, seed	
Plums	Carrots (fresh and processing)	Forage	
Strawberries	Cauliflower	Forage, seeding, new	
	Celery	Honey	
	Cucumbers (processing only)	Peanuts	
	Lettuce	Popcorn	
	Lima beans (processing only)	Soybeans	
	Parsnips	Spring grain	
	Peas (processing only)	Sugar beets	
	Peppers	Sunflowers	
	Potatoes	Wheat, red spring	
	Rutabagas	Wheat, winter	
	Seed onions	Industrial hemp	
	Set onions		
	Spanish onions		
	Squash (buttternut, processing)		
	Sweet corn (fresh and processing)		
	Tomatoes (processing)		

Insurance contracts for all other crops are available from AGRICORP Territory Managers.

APPENDIX E.
Diagnostic Service

Samples for disease diagnosis, insect or weed identification, nematode counts and Verticillium testing can be sent to:

Pest Diagnostic Clinic
Laboratory Services Division
University of Guelph
95 Stone Road West
Guelph Ontario, N1H 8J7
Tel (519) 767-6256
Fax (519) 767-6240
E-mail pdc@lsd.uoguelph.ca
Web site: www.uoguelph.ca/PDC

Payment must accompany samples at the time of submission.

Fee Schedule

Procedures	Price/ Sample
Plant Diseases	
Diagnosis not requiring plating	$25.00
Diagnosis requiring plating	$40.00
Turf diagnosis	$50.00
Bacterial identification using Biolog®	$95.00
Detection of virus using Transmission Electron Microscopy	$85.00
Detection of virus using ELISA (turnaround time = 5 working days)	$60.00
Detection of virus using ELISA (RUSH: 24-hour turnaround. Available for samples received Monday through Thursday. Each additional sample is $20.00. ELISA tests not available for all viruses, contact clinic staff for details.)	$120 for 1–6 samples
Weed identification	$40.00
Insects	
Basic identification	$25.00
Identification requiring dissection and/or extensive keys	$40.00

Nematode and Verticillium Counts	Price/ Sample
Nematodes extracted from soil (Bearman Pan Method)	$25.00
Nematodes extracted from roots	$60.00
Verticillium count	$60.00
SCN cyst count + egg count	$35.00

A minimum fee of $25.00 should accompany all submissions.

Payment: Please make cheque payable to the University of Guelph. Additional charges will be invoiced with the final report. VISA and Mastercard are also accepted. Please do not mail cash.

How to Sample for Nematodes

Soil

When to Sample

Soil and root samples can be taken at any time of the year that the soil is not frozen. In Ontario, nematode soil population levels are generally at their highest in May and June and again in September and October.

How to Sample Soil

Use a soil sampling tube, trowel or narrow-bladed shovel to take samples. Sample soil to a depth of 20–25 cm (8–10 in.). If the soil is bare, remove the top 2 cm (1 in.) prior to sampling. A sample should consist of 10 or more subsamples combined. Mix well. Then take a sample of ½–1 L (1 pint–1 quart) from this. No one sample should represent more than 2.5 ha (6.25 ac). Mix subsamples in a clean pail or plastic bag.

Sampling Pattern

If living crop plants are present in the sample area, take samples within the row and from the area of the feeder root zone (with trees, this is the drip line).

Number of Subsamples

Based on the total area sampled:

500 m^2 (5,400 ft^2)	10 subsamples
500 m^2–0.5 ha (5,400 ft^2–1.25 ac)	25 subsamples
0.5 ha–2.5 ha (1.25–6.25 ac)	50 subsamples

Roots

From small plants, sample the entire root system plus adhering soil. For large plants, 10–20 g (½–1 oz.) dig fresh weight from the feeder root zone and submit.

Problem Areas

Take soil and root samples from the margins of the problem area where the plants are still living. If possible, also take samples from healthy areas in the same field. If possible, take both soil and root samples from problem and healthy areas in the same field.

Sample Handling

Soil Samples

Place in plastic bags as soon as possible after collecting.

Root Samples

Place in plastic bags and cover with moist soil from the sample area.

Storage

Store samples at 5–10°C (40–50°F) and do not expose them to direct sunlight or extreme heat or cold (freezing). **Only living nematodes can be counted. Accurate counts depend on proper handling of samples.**

Submitting Plant for Disease Diagnosis or Identification

Sample Submission Forms

Carefully fill in all of the categories on the form. In the space provided, draw the most obvious symptom and the pattern of the disease in the field. It is important to include the cropping history of the area for the past 3 years and this year's pesticide use records.

Choose a complete, representative sample showing early symptoms. Submit as much of the plant as is practical, including the root system, or several plants showing a range of symptoms. For turfgrass, submit a 10–15 cm^2 piece of turf, including thatch and at least 5 cm of soil. Take the sample from the outside edge of a ring or patch, and include healthy and unhealthy turf, as well as the interface between. If symptoms are general, collect the sample from an area where they are of intermediate severity. **Completely dead material is usually inadequate for diagnosis**.

With plant specimens submitted for identification, include at least a 20–25-cm sample of the top portion of the stem with lateral buds, leaves, flowers or fruits in identifiable condition. Wrap plants in newspaper and put in a plastic bag. Tie the root system off in a separate plastic bag to avoid drying out and contamination of the leaves by soil. Do **NOT** add moisture, as this encourages decay in transit. Cushion specimens and pack in a sturdy box to avoid damage during shipping. Avoid leaving specimens to bake or freeze in a vehicle or in a location where they could deteriorate.

Delivery

Deliver to the Pest Diagnostic Clinic as soon as possible by first class mail or by courier at the beginning of the week.

Submitting Insect Specimens for Identification

Collecting Samples

Place dead, hard-bodied insects and spiders in vials or boxes and cushion with tissues or cotton. Place soft-bodied insects and caterpillars in vials containing alcohol. Do not use water, as this results in rot. Do not tape insects to paper or send them loose in an envelope.

Place live insects in a container with enough plant "food" to support them during transit. Be sure to write "live" on the outside of the container.

APPENDIX F.
The Metric System

Metric Units

Linear Measures (length)		
10 millimetres (mm)	=	1 centimetre (cm)
100 centimetres (cm)	=	1 metre (m)
1,000 metres	=	1 kilometre (km)
Square Measures (area)		
100 m X 100 m = 10,000 m^2	=	1 hectare (ha)
100 ha	=	1 square kilometre (km^2)
Cubic Measures (volume)		
Dry Measure		
1,000 cubic millimetres (mm^3)	=	1 cubic centimetre (cm^3)
1,000,000 cm^3	=	1 cubic metre (m^3)
Liquid Measure		
1,000 millilitres (mL)	=	1 litre (L)
100 L	=	1 hectolitre (hL)
Weight-Volume Equivalents (for water)		
(1.00 kg) 1,000 grams	=	1 litre (1.00 L)
(0.50 kg) 500 g	=	500 mL (0.50 L)
(0.10 kg) 100 g	=	100 mL (0.10 L)
(0.01 kg) 10 g	=	10 mL (0.01 L)
(0.001 kg) 1 g	=	1 mL (0.001 L)
Weight Measures		
1,000 milligrams (mg)	=	1 gram (g)
1,000 g	=	1 kilogram (kg)
1,000 kg	=	1 tonne (t)
1 mg/kg	=	1 part per million (ppm)
Dry–Liquid Equivalents		
1 cm^3	=	1 mL
1 m^3	=	1000 L

Application Rate Conversations

Metric to Imperial (Approximate)		
litres per hectare x 0.09	=	gallons per acre
litres per hectare x 0.36	=	quarts per acre
litres per hectare x 0.71	=	pints per acre
millilitres per hectare x 0.015	=	fluid ounces per acre
grams per hectare x 0.015	=	ounces per acre
kilograms per hectare x 0.89	=	pounds per acre
tonnes per hectare x 0.45	=	tons per acre

Imperial to Metric (Approximate)		
gallons per acre x 11.23	=	litres per hectare (L/ha)
quarts per acre x 2.8	=	litres per hectare (L/ha)
pints per acre x 1.4	=	litres per hectare (L/ha)
fluid ounces per acre x 70	=	millilitres per hectare (mL/ha)
tons per acre x 2.24	=	tonnes per hectare (t/ha)
pounds per acre x 1.12	=	kilograms per hectare (kg/ha)
ounces per acre x 70	=	grams per hectare (g/ha)

Liquid Equivalents

Litres/Hectare		*Approximate Gallons/Acre*
50	=	5
100	=	10
150	=	15
200	=	20
250	=	25
300	=	30

Dry Weight Equivalents

Grams or Kilograms / Hectare		*Ounces or Pounds /Acre*
100 grams	=	1½ ounces
200 grams	=	3 ounces
300 grams	=	4¼ ounces
500 grams	=	7 ounces
700 grams	=	10 ounces
1.10 kilograms	=	1 pound
1.50 kilograms	=	1¼ pounds
2.00 kilograms	=	1¾ pounds
2.50 kilograms	=	2¼ pounds
3.25 kilograms	=	3 pounds
4.00 kilograms	=	3½ pounds
5.00 kilograms	=	4½ pounds
6.00 kilograms	=	5¼ pounds
7.50 kilograms	=	6¾ pounds
9.00 kilograms	=	8 pounds
11.00 kilograms	=	10 pounds
13.00 kilograms	=	11½ pounds
15.0 kilograms	=	13½ pounds

Metric Conversions		
5 mL	=	1 tsp
15 mL	=	1 tbsp
28.5 mL	=	1 fl. oz

Conversion Tables — Metric to Imperial

Length		
1 millimetre (mm)	=	0.04 inch
1 centimetre (cm)	=	0.40 inch
1 metre (m)	=	39.40 inches
1 metre (m)	=	3.28 feet
1 metre (m)	=	1.09 yards
1 kilometre (km)	=	0.62 mile
Area		
1 square centimetre (cm^2)	=	0.16 square inch
1 square metre (m^2)	=	10.77 square feet
1 square metre (m^2)	=	1.20 square yards
1 square kilometre (km^2)	=	0.39 square mile
1 hectare (ha)	=	107,636 square feet
1 hectare (ha)	=	2.5 acres
Volume (dry)		
1 cubic centimetre (cm^3)	=	0.061 cubic inch
1 cubic metre (m^3)	=	1.31 cubic yards
1 cubic metre (m^3)	=	35.31 cubic feet
1,000 cubic metres (m^3)	=	0.81 acre-foot
1 hectolitre (hL)	=	2.8 bushels
Volume (liquid)		
1 millilitre (mL)	=	0.035 fluid ounce
1 litre (L)	=	1.76 pints
1 litre (L)	=	0.88 quart
1 litre (L)	=	0.22 gallon (Imp.)
1 litre (L)	=	0.26 gallon (U.S.)
Weight		
1 gram (g)	=	0.035 ounce
1 kilogram (kg)	=	2.21 pounds
1 tonne (t)	=	1.10 short tons
1 tonne (t)	=	2,205 pounds
Pressure		
1 kilopascal (kPa)	=	0.15 pounds/in^2
Speed		
1 metre per second	=	3.28 feet per second
1 metre per second	=	2.24 miles per hour
1 kilometre per hour	=	0.62 mile per hour
Temperature		
°F	=	(°C X 9/5) + 32

Conversion Tables — Imperial to Metric

Length		
1 inch	=	2.54 cm
1 foot	=	0.30 m
1 yard	=	0.91 m
1 mile	=	1.61 km
Area		
1 square foot	=	0.09 m^2
1 square yard	=	0.84 m^2
1 acre	=	0.40 ha
Volume (dry)		
1 cubic yard	=	0.76 m^3
1 bushel	=	36.37 L
Volume (liquid)		
1 fluid ounce (Imp.)	=	28.41 mL
1 pint (Imp.)	=	0.57 L
1 gallon (Imp.)	=	4.55 L
1 gallon (U.S.)	=	3.79 L
Weight		
1 ounce	=	28.35 g
1 pound	=	453.6 g
1 ton	=	0.91 tonne
Pressure		
1 pound per square inch	=	6.90 kPa
Temperature		
°C	=	(°F – 32) x 5/9

Abbreviations

%	= per cent (by weight)	km/h	= kilometres per hour
ai	= active ingredient	kPa	= kilopascal
AP	= agricultural powder	L	= litre
cm	= centimetre	m	= metre
cm^2	= square centimetre	m/s	= metres per second
DG	= dispersible granular	m^2	= square metre
DP	= dispersible powder	mL	= millilitre
E	= emulsifiable	mm	= millimetre
e.g.	= for example	SC	= sprayable concentrate
EC	= emulsifiable concentrate	SP	= soluble powder
F	= flowable	t	= tonne
g	= gram	W	= wettable (powder)
Gr	= granules, granular	WDG	= water dispersible granular
ha	= hectare	WP	= wettable powder
kg	= kilogram	km/h	= kilometres per hour

Spraying Application Record

Application Equipment Used	Tank Capacity	Nozzle Type & Pressure	Tractor Speed or Gear and RPM	Calibrated Application Rate per hectare or acre

Comments

Application Information								Environment Information		
Field Identification	Location & Size	Application Date & Time	Crop & Stage of Growth	Product (Concentration)	Product (rate/ha or acre)	Water (Rate/ha or acre)	No. of Tanks (per field)	Wind Speed & Direction	Temperature	Soil Moisture

Emergency and First-Aid Procedures for Pesticide Poisoning

- Become familiar with the chemicals you are using. Keep a list of common names in case of accidents or emergencies. This information can be found on the product labels and cross-referenced in this publication.
- If a pesticide has come in contact with the skin or has been spilled on clothing, remove the clothing and wash the skin thoroughly with soap and warm water.
- If pesticide has come in contact with the eyes, rinse them with plenty of clean water for 15 minutes. Repeat this procedure.
- If a person suspects poisoning from exposure to a pesticide by swallowing, inhalation, or contact with skin or eyes, read the label on the pesticide container and carry out the first-aid treatment suggested.
- **Immediately after first-aid treatment has been given, wrap the patient in a coat or blanket and rush him/her to the nearest hospital. Take the list of chemical common names with you and identify the ones being used.**
- **If a person is unconscious or lapses into unconsciousness, call an ambulance immediately.**
- **Emergency advice on pesticide poisoning is available from the Regional Poison Information Centres at:**

  Toronto 1-800-268-9017 Ottawa (bilingual) 1-800-267-1373

- **Those needing hearing assistance should call: 1-416-597-0215 (TTY)**

  Emergency telephone numbers are listed at the front of each Bell telephone directory.

  Fill in the following:

  My Local Poison Information Centre Telephone Number is:

  _____-_____

For information, or to obtain copies of this or any other ministry publication, please: call 1-888-4-OMAFRA (1-888-466-2372) from within Ontario, (519) 826-3700 from outside the province or OMAFRA's TTY line at (519) 826-7402 for the hearing impaired, email your request to *products@omafra.gov.on.ca*, or visit OMAFRA's web site at *www.gov.on.ca/omafra*.

A complete listing of all OMAFRA products and services, and order forms, are available on the web site. Orders can be faxed to (519) 826-3633 or mailed to Government Information Centre, OMAFRA, 1 Stone Road West, Guelph, ON N1G 4Y2

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